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Florida Power Corporation Crystal River Units 4 and 5

Technical Support Documents
Volume II

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CHAPTER 6

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6.0 ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

6.1 BASELINE MONITORING AND RELATED INFORMATION

Investigations were conducted through literature searches and field studies to determine the nature of existing environments. Past studies of the Crystal River site in connection with Units 1, 2, and 3 provided many references. Literature concerning similar habitats in the State of Florida and the southeastern United States were also useful. Studies directly concerned with the Site Certification Application are delineated in the following text.

6.1.1 SURFACE WATER

Information concerning surface water hydrology in the area was obtained from 15 published reports. Most of these were either USGS reports or reports dealing with the hydrology of the Cross-Florida Barge Canal. The USGS Water Resources Data for Florida (1975 and 1976) provided information concerning the discharges of major streams in the area, as well as water quality analyses. All measurements were obtained by the USGS. Several other reports (i.e., Rabon, 1967; Kaufman, 1975; Kenner, 1966) provided statistical interpretations of data contained in the Water Resources Data books. Cherry (1970) provided a general overview of hydrology in the region and a water budget analysis. Bush (1972) reported on saltwater movement in the lower Withlacoochee River based on chemical analyses of water taken from 11 sites on the lower Withlacoochee-Cross Florida Barge Canal. Tidal data was also obtained from this report based on water level recordings taken at Crackertown, Florida, since 1967.

The reports concerning the hydrology of the Cross-Florida Barge Canal (i.e., U.S. Army Corps of Engineers, 1976; Meta Systems, 1976) provided detailed statistical interpretations of discharges in the lower Withlacoochee River. Much of this information was not totally relevant to the study area. The Corps of Engineer's Water Resources Study of the Four River Basins Area (1977) provided some more recent information concerning the discharge characteristics of both the Withlacoochee River and the Crystal River.

Information concerning flooding in the area was obtained from two sources, an Army Corps of Engineers's Flood Hazard Information Study for the lower Withlacoochee (1976) and USGS Flood-Prone Area Maps (1954) for the study site. The Corps of Engineers' report was not wholly representative of the study area, in that structures associated with the barge canal serve to lessen flooding effects at the mouth of the Withlacoochee. The 100-year flood elevation of the site was estimated through the use of readily available information on past floods rather than from detailed field surveys and inspections.

Additional information concerning the physical characteristics of Lake Rousseau and Crystal River was obtained during studies conducted in August 1977 (Environmental Science and Engineering, Inc., 1977).

6.1.2 WATER QUALITY

Most of the baseline data discussed in Subsection 2.5.2 concerning the water quality in the estuary, intake, and discharge canals was taken from existing literature.

Water quality parameters investigated by Gibson, et al. (1974), were discussed. This investigation was initiated in 1973 to determine seasonal patterns of phytoplankton standing crop and production and water quality in Gulf coastal waters adjacent to the Florida Power Corporation generating facility at Crystal River. Water samples were collected bi-weekly for the six-month period from November 1973 to April 1974. Sampling locations were chosen to include points in the intake canal, discharge canal, and discharge basin, and to estimate the impact of the two principal freshwater sources on the region. Nutrient concentrations were assayed, using a 2-Channel Technicon Autoanalyzer (AII), following procedures outlined by Hopkins (1966). Salinities were measured using a Beckman salinometer, temperature was measured with a mercury thermometer, and chlorophyll a by the procedures of Strickland and Parsons (1968).

Phosphorus values discussed were taken from Odum and Snedaker (1971). This report discussed the processes within the plume-receiving ecosystem at Crystal River. Preliminary analysis was performed for phosphorus, chlorophyll a, and phaeo-pigments. These results, as well as those of benthic studies, are presented in order to develop a model of the system.

Solids and turbidity data discussed were taken from Fox and Moyer (1970). The specific objectives of this study were to determine, by using various parameters, the direct and indirect effects of chlorinated cooling water on the microbiota of the receiving waters. In order to measure the effects of chlorination, the following assays were performed: temperature, dissolved oxygen, chlorophyll a, primary productivity, Adenosine Triphosphate (ATP), total bacterial populations, total solids, suspended solids, volatile solids, secchi disc, and chlorine.

Temperature and salinity data discussed were taken from Behrens and Carder, 1975. This report presents and analyzes salinity and temperature data collected from April 1974, through March 1975, in the Florida Power discharge basin at Crystal River, Florida, with respect to seasonality and plume acreages.

Additional information concerning the quality of surface waters in the vicinity of the proposed site was obtained from Florida Department of Environmental Regulation Water Quality Management Plans for the Tampa Bay Area (1976) and the Withlacoochee River Basin (1975). These plans evaluated numerous water quality analyses of selected sites on the Crystal River and the Withlacoochee River against the water quality standards which have been adopted for these waters. On the basis of these evaluations, qualitative determinations were reported concerning the water quality in these streams.

The baseline data presented for Crystal River and Lake Rousseau in Chapter 2 was collected by ESE in late August 1977 (Figures 6.1-1 and 6.1-2).

Site locations on Crystal River were situated 1.6 kilometers (1 mile) above, 1.6 kilometers (1 mile) below, and at the proposed intake site. Grab samples were taken from the surface and from near the bottom at each of these sites and returned to ESE for analysis. Analyses which were performed and analytical methodologies used can be seen in Table 6.1-1. In situ analyses were also performed at the surface and near the bottom at each of the three sites. In situ methodologies are presented in Table 6.1-2.

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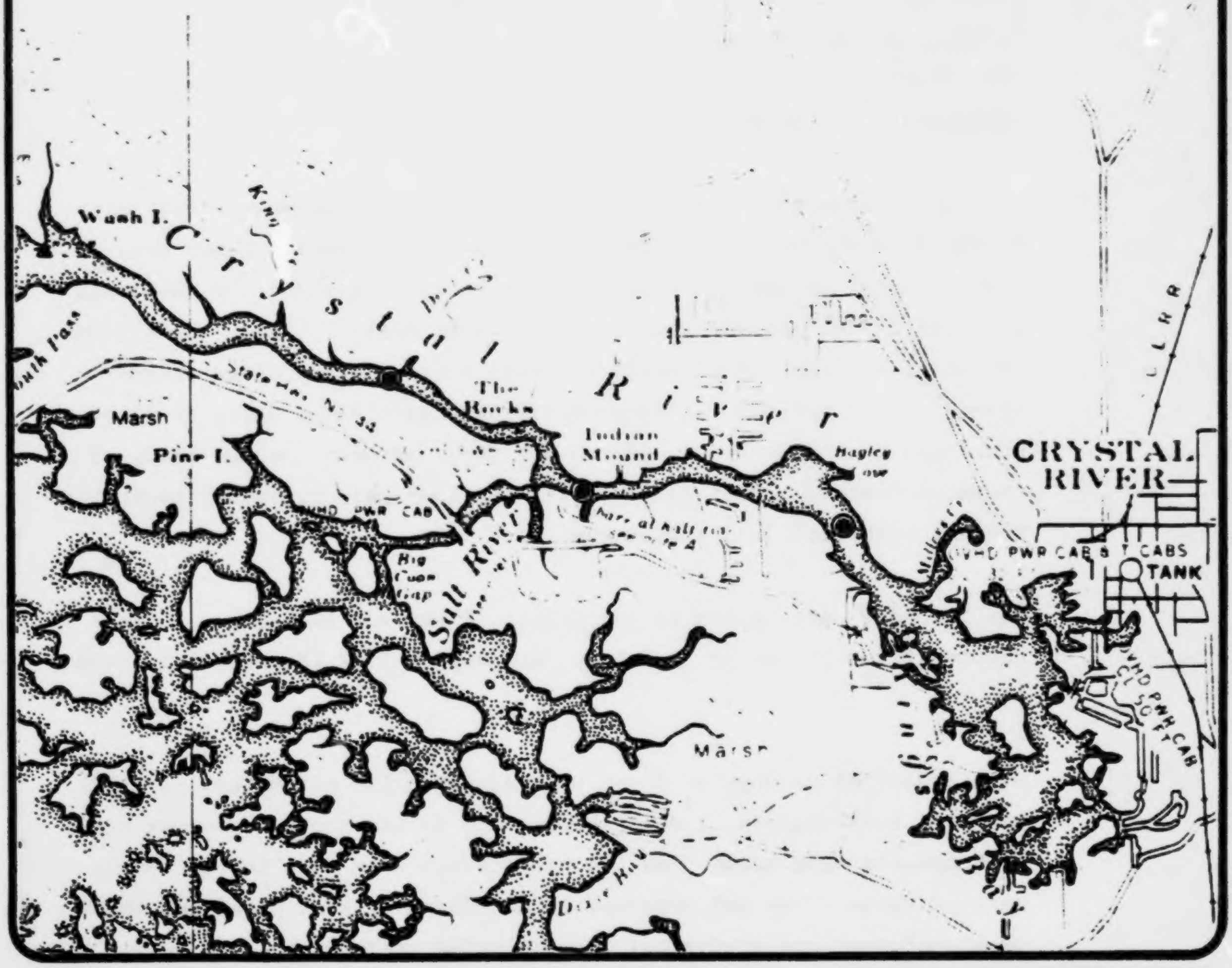

Figure 6.1-1
CHEMICAL SAMPLING SITES, CRYSTAL RIVER

N
0 1
SCALE IN MILES

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1977

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CITRUS COUNTY, FLORIDA

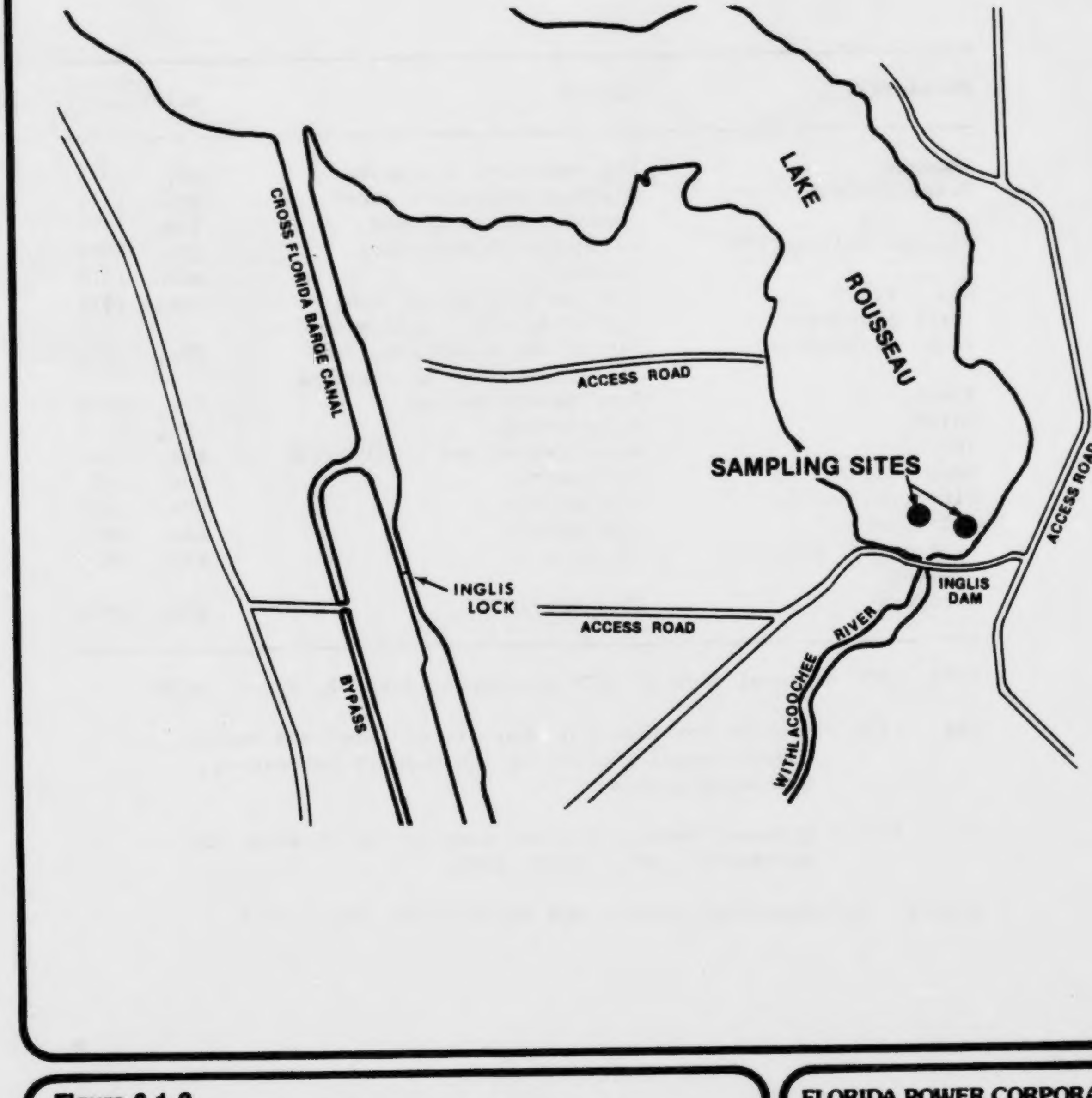

Figure 6.1-2
CHEMICAL SAMPLING SITES, LAKE ROUSSEAU

SOURCE: ENVIRONMENTAL SCIENCE
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Table 6.1-1 Chemical Analysis of Water Samples

Parameter	Method	Reference
Ammonia	NH_3 selective ion probe	SM, 1975
Total Kjeldahl nitrogen	Kjeldahl digestion automated phenate method	EPA, 1976 EPA, 1976
Nitrate and nitrite	Automated Cd reduction method	EPA, 1976 ASTM, 1976
Dissolved orthophosphate	0.45 um filtration, automated ascorbic acid method	EPA, 1976
Total phosphorus	Persulfate digestion, automated ascorbic acid method	EPA, 1976
Alkalinity	Titrimetric method	EPA, 1976
Color	Colorimetric	EPA, 1976
Turbidity	Nephelometer and Secchi disk	EPA, 1976
Suspended solids	Gravimetric	EPA, 1976
Dissolved solids	Gravimetric	EPA, 1976
Total solids	Gravimetric	EPA, 1976
Biochemical oxygen demand	DO probe	EPA, 1976
Hardness	Titrimetric	EPA, 1976

ASTM, 1976 = Annual Book of ASTM Standards, Part 31, Water, ASTM.

EPA, 1976 = Methods for Chemical Analysis of Water and Wastes, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

SM, 1976 = Standard Methods for the Examination of Water and Wastewater, APHA, WPCF, AWWA.

Source: Environmental Science and Engineering, Inc., 1978.

Table 6.1-2 *In-Situ* Analysis of Water

Parameter	Method	Reference
Temperature	Thermistor	EPA, 1976
pH	Hydrogen ion electrode	EPA, 1976
Dissolved oxygen	DO probe	EPA, 1976
Salinity	Electrical conductivity method	SM, 1975

EPA, 1976 = Methods for Chemical Analysis of Water and Wastes, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

SM, 1975 = Standard Methods for the Examination of Water and Wastewater, APHA, WPCF, AWWA.

Source: Environmental Science and Engineering, Inc., 1980.

There were two site locations at Lake Rousseau: a nearshore site situated near the proposed intake site, and an offshore site situated approximately .4 kilometer (.25 mile) east of Inglis Dam (Figure 6.1-2, Lake Rousseau site locations). Grab samples were taken from the surface and from near bottom at each of these sites and returned to ESE for analysis. Table 6.1-1 presents the analyses which were performed, and analytical methodologies used. _In situ_ analyses were also performed at the surface and near the bottom at both sites. _In situ_ methodologies are presented in Table 6.1-2.

6.1.3 ECOLOGICAL PARAMETERS

SALT MARSH

Information gathered on the salt marsh biota was based on the existing literature. Reference to Hosner, McMahan, McKellar, and Young is from a ten-month study undertaken during the period from May 1974 to February 1975, in the Crystal River region of Florida. Hosner discussed the seasonal variation, biomass, diversity, and trophic structure of fish in the salt marsh tidal creeks. He also gives a brief discussion of the various predominant species collected. McMahon discusses briefly the microarthropod population present in the area. As mentioned in Section 2.7, the limited degree to which these organisms were identified precluded detailed conclusions relating population interaction or relationships with other trophic levels.

McKellar summarized the outer bay ecosystem at Crystal River, Florida, in terms of metabolism and energy flow models. He also discussed total system turnover times based on system metabolism and organisms' biomasses.

Young extensively discusses the salt marshes and the effects of thermal inundation in terms of plant standing crop, net production, respiration, total metabolism, decomposition, diversity, and selected animal members (specifically, the marsh periwinkle, Littorina irrorata, and the fiddler crab, Vea sp.). Effects were incorporated into energy flow diagrams to better understand the system on a community level. These results were compared to those found in the literature. There were also two sampling periods, May and September, at Jacksonville, Florida, on the St. John's River for comparisons of Spartina, Littorina irrorata, and Vea sp. abundances.

Keefe (1972) reviewed studies on fresh and saltwater marsh production and discussed their high productivity in comparison to terrestrial and phytoplankton communities. The role of the marsh flora as a food source was also discussed. She points out the failure in recent research to ascertain the value of marsh detritus to the adjoining water body.

Cuzon du Rest (1963) studied the distribution of zooplankton in the salt marshes of southeastern Louisiana. This study was done in terms of seasonal (temporal) distribution and geographic (spatial) variance in salinity from nearly fresh water to nearly marine water (the total range was from 0.5 ppt to 25.4 ppt). Monthly abundances were determined for the numerically important species. Day (1973) carried du Rest's work one step further and determined respiration/production rates, as well as that quantity lost to higher trophic levels via waste for the single most abundant zooplankton, the copepod (*Acartia tonsa*). This species was found to be the major component in other areas, specifically Florida, based on work done by Hopkins (1966) at St. Andrews Bay and Woodmansee in Biscayne Bay. Hopkins ascertained the number of generations of *A. tonsa* in a given year to be about 11.

Maturo, *et al*. (1974), characterized the zooplankton population in the Crystal River estuary. The characterization was based on the distribution and structure of the zooplankton populations from July 1972 to July 1973. Sites were categorized as inshore, intermediate, and offshore. Salinity, temperature, and other environmental readings were taken with each sample. Within this report, Alden and Hearne discuss zooplankton production based on *A. tonsa*. Two methods were used to determine production. The first was based on computation of turnover time, which in turn was based on instantaneous death rates estimated from population age structures observed in the field and development time as determined by laboratory experimentation. A second method was used, based on metabolism. Here, using the proper assumptions, production is equivalent to the carbon assimilated less the carbon respiratory cost [which is equal to milliliters of oxygen consumed times 1.4 (density of oxygen) times .375 (ratio of carbon to oxygen in glucose) divided by the carbon weight of the animals)]. Also within this report, Hallquist discussed ctenophore standing crop and predation.

Standing crop was determined as a volume per cubic millimeter. Predation was determined in two ways: the first is based on the theory that feeding rate is a function of copepod concentration and ctenophore size; and the second on production values (specifically, total carbon ingested divided by total carbon available as zooplankton standing crop).

Carr and Giesel (1975) sampled marshland creeks near a steam-electric station near Jacksonville, Florida. The purpose of their study was to compare fish populations in thermally impacted marshland creeks to a population by the plant's effluent. Using a seine to collect samples, 48 different species were collected. Abundances and biomass per unit area for utilizable (defined here as those fishes used by man either as food or for various fish products) juveniles as well as values for the entire fish population over the time period of the study (June, July, and September) were ascertained. One major shortcoming of this report was its failure to statistically analyze differences at the various sites.

Harrington (1961), in his paper on ecology, discusses food selection of fishes in different habitats, including a salt marsh. He explains how the selection of prey shifts both spatially and temporally from the onset of flooding through the progress of a mosquito brood.

Reid (1954) and Springer's (1960) reports reviewed the general ecological trends of fish communities in Florida. Reid's work was done in the vicinity of Cedar Key, while Springer's report was done in the Tampa Bay area. Both authors point out that juveniles appear in the estuary during the late spring and early summer months. Sykes (1966) reconfirms this time of occurrence in his work on the appearance of juveniles of the dominant commercial fishes in the Gulf of Mexico.

AQUATIC HABITATS ON THE PROPOSED CONSTRUCTION SITE

Information concerning Florida Power's proposed location 1c was based on a single field effort undertaken by members of the aquatic group from Environmental Science and Engineering, Inc. Three transects, which ran south to north, were sampled. One transect ran along the western boundary of the proposed site (Transect 1), one along the eastern boundary (Transect 3), and the third ran midway between the two (Transect 2). The distances between the transects were approximately .8 kilometer (0.5 mile), and the total length of each was .8 kilometer (0.5 mile).

At various wet sites along each transect, a ponar sample was taken and, where it appeared applicable, dip net samples were taken. Ponar samples were sieved through a #30 mesh, all samples were preserved in 10 percent formalin, and returned to the lab where they were identified.

Site A on Transect 1 was the site farthest north and samples were taken in what appeared to be a permanent marsh; Site B was one of two small [approximately 3 meters (10 feet) in diameter], shallow, sandy bottom ponds in an open area; Site C had standing water approximately 46 centimeters (18 inches) deep with a litter-covered bottom; Site D was a "permanent pond" in thick woods with a leaf litter bottom; Site E was a habitat similar to that found at Site C. Small fish, tadpoles, dytiscids, hemipterans, and frogs were observed at the various sites.

Transect 2 would have been inaccessible except for a road which ran just west of and parallel to the transect. This road was traveled and, when possible, stops were made and short excursions were undertaken east to cross the proposed transect. A total of four such walks were made. Five of six "water holes" were observed; three or four were small wallows [less than 2 meters (7 feet) in diameter], and two appeared to be relatively major water reserves [greater than 3 meters (10 feet) in diameter with flora frequently associated with water systems observed in the vicinity, e.g., sawgrass, arrowhead, pickeral weed, and spatter dock]. All were dry. No streams or stream-like systems were noted.

Transect 3 was inaccessible with the exception of the very northern border and just south [.2 kilometer (.13 mile)] of the southern border. However, based on these two observations (observations at Transect 2 and gross observations in the general vicinity of Transect 3), no water is believed to be present.

At a later date, members of the terrestrial group of Environmental Science and Engineering, Inc., surveyed the area and noted several water bodies in the general vicinity of Transects 2 and 3. However, minimal faunal activity was noted in these systems, and the substrate appeared to be hard limestone with minimal litter present.

TERRESTRIAL COMMUNITIES

Wharton, et al. (1976), described the forested wetlands of the region in a general sense, while Pearson (1954) described the mammals of the similar Gulf Hammock area in Levy County, which occurs about 16 kilometers (10 miles) north of the site.

Numerous studies have been carried out by the U.S. Forest Service and the Florida Game and Fresh Water Fish Commission as part of the Cross Florida Barge Canal Restudy Report (U.S. Army Corps of Engineers, 1976). While most of the information was gathered along the more easterly reaches of the canal, specific data on such items as forest stand composition and endangered species occurrence were gathered for the western end of the canal, which terminates about 5 kilometers (3 miles) north of the plant site.

Studies carried out between 1969 and 1976 during the environmental assessment of the Crystal River Unit 3 nuclear plant were primarily concerned with the salt marsh and estuarine systems. Terrestrial studies were largely confined to surveys of food webs and dietary habits of species in which radioactive nucleotides could accumulate (Pruit, 1971).

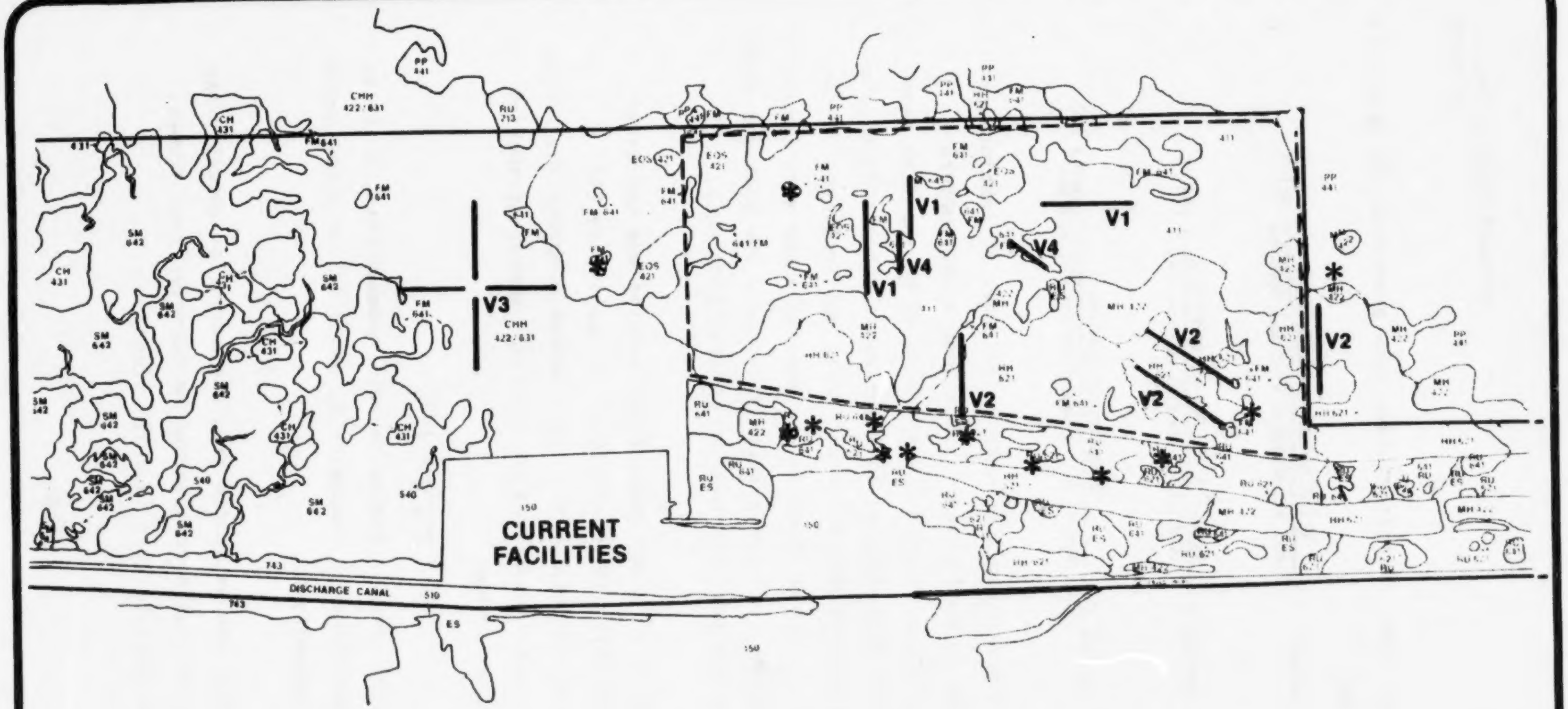
A study of potential salt spray impacts near the site (Dames & Moore, 1974) developed limited specific data on species present at the site.

Vegetative Parameters

The above studies and additional literature were used to obtain regional information. Field studies to develop site specific information took place from August 22 to August 27, 1977. Methods of vegetation analysis used are discussed in the following sections.

Overstory vegetation was inventoried for the pine flatwoods, coastal hydric hammock, and mesic/hydric hammock complex along the transect lines shown in Figure 6.1-3. The point-quarter method of Cottam and Curtis (1956) was used with eight points randomly selected on each transect line. Species:area curves (Oosting, 1956) were used to insure that an adequate number of points were sampled.

Data collected were used to generate importance values, as formulated by Curtis and McIntosh (1951). Density, basal area, and average diameter at breast height were derived for pine plantations by sampling and computing tree diameter, the average distance between trees, and the average distance between rows.



V1 VEGETATION SURVEY LINE - PINE FLATWOODS
V2 VEGETATION SURVEY LINE - MESIC/HYDRIC HAMMOCK
V3 VEGETATION SURVEY LINE - COASTAL HYDRIC HAMMOCK
V4 VEGETATION SURVEY LINE - FRESH WATER MARSH
* VEGETATION - SPOT SAMPLE

Figure 6.1-3
SAMPLING AREA LOCATIONS FOR VEGETATION

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1977

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Importance values and other parameters have been generated for overstory vegetation as follows:

$$\text{Relative density of species A} = \frac{\text{\# individuals of species A}}{\text{total \# individuals of all species}} \times 100$$

$$\text{Relative dominance of species A} = \frac{\text{total basal area of species A}}{\text{total basal area of all species}} \times 100$$

$$\text{Relative frequency of species A} = \frac{\text{frequency of species A}}{\text{sum of all frequencies for all species}} \times 100$$

Shrub vegetation includes all plants with height over 30 centimeters (12 inches) and a stem circumference of less than 2 centimeters (.8 inch). Ground cover includes all vegetation of height less than 1 meter. Both of these were sampled in 12.6-square meter (135-square feet) circular plots for estimated percent cover and frequency in two plots on each transect. Plots in marsh and ruderal areas were located at approximately 40-meter (130-foot) intervals. Only one plot per stand was used when stand width was less than 40 meters (130 feet).

The floristic similarity of plant communities sampled was expressed using Sorensen's community coefficient index of similarity (IS) (Mueller-Dombois and Ellenberg, 1974). This method compares the number of species common to both communities to the total number of species found in both communities, thus:

$$IS = \frac{2C}{A + B} \times 100$$

where C is the number of species common to both communities, A is the total number of species found in community A, and B is the total number of species found in community B.

Age of trees at the site was estimated from the number of annual rings found in core borings of trunks or observed on cut-over tree stumps. Phloroglucinol dye was used to help identify rings.

Vegetative communities at the site were mapped from 1 inch:500 feet black and white aerial photographs, and ground-truthed and refined during the field survey. The map has been compared to the draft wetlands map of the National Wetlands Inventory (U.S. Fish and Wildlife Service, 1977) and found to be in good general agreement. Minor differences are felt to be the result of higher resolution photographs and increased ground truthing used in the site survey. The regional vegetation map was prepared from a 1 inch:2000 feet black and white aerial photograph. In addition to the information gathered by these methods, qualitative observations were recorded about each community in regard to hydroperiod, evidence of fire, human disturbance, and various other factors. Estimates of depth of surface soils were made by inserting a .63 kilometer (.25 inch) diameter brass rod into the soils.

Taxonomic determinations were based primarily upon the following sources: Kurz and Godfrey, 1962; Long and Lakela, 1971; Radford, et al., 1968; Rickett, 1966; and Wherry, 1964.

Fauna

The primary objective of the faunal sampling program was to verify the mammal, bird, reptile, and amphibian species occurring in the area and to determine the relative abundance of each species. Strict quantitative techniques involving mammal trapping, drift nets, mist nets, etc., were determined to be unnecessary for the proposed project. Instead, diurnal and nocturnal visual/auditory searches were made throughout the site, with frequency of observation recorded for each species. Qualitative trapping efforts were conducted to establish the presence of small mammal populations in various habitats. In addition, habitat evaluations were made to determine the possible habitat utilization by important species and rare and endangered animals. A literature survey was conducted for the area of the plant site.

Small mammal trapping was accomplished with a Sherman live trap, victor mouse trap, victor rattrap, and a pitfall. One trap line with 20 stations was placed in a longleaf pine/evergreen oak scrub, a mesic/hydric hammock, and in coastal hydric hammock communities (Figure 6.1-4). Stations were located 10 meters (33 feet) apart, and each had one Sherman live trap and two victor snap traps. In addition, 7 pitfall traps (a # 10 galvanized can) were placed along each line. Nine traps were baited with a mixture of peanut butter and oatmeal and prebaited for 2 days. Lines were inspected daily and rebaited for 3 days. All species caught were noted, as were the habitat types.

Habitat evaluation was made for each type found at the site. Primary objectives were to evaluate tracts of lands for their suitability as habitat for the more important species, namely deer, squirrel, quail, turkey, and rare and endangered animals. Habitat evaluation was made in each major ecosystem based on various types of cover, availability of food, water sources, and denning sites or nesting areas. Information was generated by walking transects and recording habitat conditions and species observed. Information on food sources was taken primarily from the vegetative sampling. The purpose of these techniques was to give a practical means for assessment of habitats with regard to some of the more important species. In addition, areas with dense understory and ground cover of palmetto were only partially inventoried because of the limited accessibility. Preferred habitat, number observed, seasonal occurrence (birds only), and relative abundance have been given for each species. Relative abundance is classed as follows:

A = Abundant; encountered nearly every time preferred habitat was visited.
C = Common; encountered most of the time in preferred habitat.
U = Uncommon; may be encountered irregularly in preferred habitat.
R = Rare; encountered very infrequently in preferred habitat.

A literature survey was conducted for references pertinent to the general physiographic region and to the plant site in particular. Perhaps

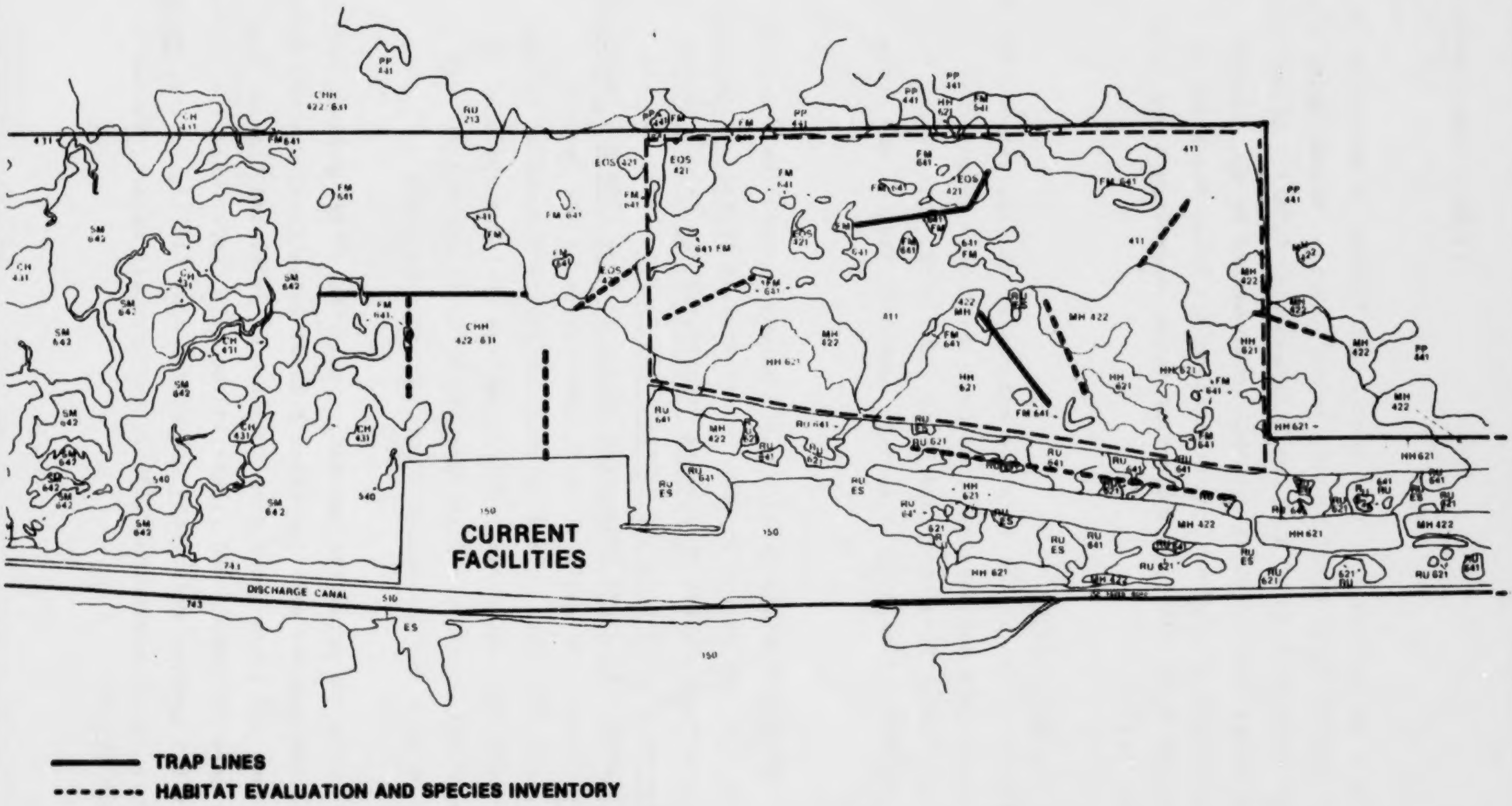

Figure 6.1-4
SAMPLING AREA LOCATIONS FOR FAUNA

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the best work on the fauna of this section of Florida is presented in the Cross Florida Barge Canal Restudy Report (1976). Nomenclature for the mammals follows that of Burt and Grossenheider (1964). Scientific and common names for the birds are those recommended by the Thirty-Second Supplement to the American Ornithologists Union Checklist of North American Birds (1973). The herpetofauna nomenclature was taken from Conant (1975).

Rare and Endangered Fauna

The primary objective of the rare and endangered species methods was to identify those rare and endangered species which have ranges that include the Crystal River proposed power plant site, Units 4 and 5. Sources used for delineation of species were both federal and state listings.

The U.S. Fish and Wildlife Service publications include the existing listings at the time of the document's preparation (United States List of Endangered Fauna, 1974; Threatened Wildlife of the United States, 1973; Endangered and Threatened Wildlife and Plants, 1977) and the proposed listing (Proposed Endangered Status on Some 1700 U.S. Vascular Plant Taxa, 1976). In addition, each publication of the Federal Register since 1977 was checked in order to verify additional species listed as rare and endangered. State listings included those of the Florida Game and Freshwater Fish Commission (1974) and the Florida Committee on Rare and Endangered Plants and Animals (1976).

References used for preferred habitat, likelihood of occurrence, and ecology of the species were the Cross Florida Barge Canal Restudy Report (Florida Game and Fresh Water Fish Commission, 1976) and Florida Committee on Rare and Endangered Plants and Animals (1977) unless otherwise stated. Other general references included Conant (1975), Robins, *et al.* (1966), Burt and Grossenheider (1964), and Archbold Report, Volume I, II, and III (1977).

In addition to the general survey work for each species, special surveys and data reviews were conducted for three species for which on-site population estimates are difficult. These are the eastern indigo snake, the short-tailed snake, and the Florida manatee.

Eastern Indigo Snake

The eastern indigo snake occurs locally in peninsular Florida, in a few widely scattered areas of the Georgia Coastal Plain, and in parts of the Florida panhandle. This snake occupies a wide variety of habitat types. The indigo snake is a species of high humidity requirements, however, it can survive in xeric environments, if gopher tortoise burrows are present (Kochman, 1976). According to the Cross Florida Barge Canal Restudy Report (Florida Game and Fresh Water Fish Commission, 1976) the occurrence of indigo snake in similar type habitats as found on the proposed site is as follows:

Coastal Hammock--Occasional,
Hydric Hammock--Frequent,
Mesic Hammock--Occasional,
Xeric Hammock--Occasional,
Slash Pine Flatwoods--Occasional,
Pine Plantation--Infrequent, and
Evergreen Oak Scrub--Occasional.

During ecological surveys of these types of habitats on the property, the indigo snake was not observed; however, it has been reported to occur on the site (Voigts, 1977). The proposed site is considered good habitat for indigo snakes because of the diversity of habitat; the numerous area of thickets, brush piles, and other organic debris; and the apparently large populations of rodents and other herpetiles.

In response to specific questions by the Environmental Protection Agency and the United States Fish and Wildlife Service concerning population studies and site specific information on the indigo snake, various authorities (Dr. Roy McDirmid and Dr. Howard W. Campbell) were contacted. It was found that no site specific information was available nor were there presently proven methods for precisely estimating population densities of this species. Dr. Howard Campbell (1978) recommended searches be conducted in likely habitat to roughly evaluate populations of indigo snake.

Short-Tailed Snake

The short-tailed snake is a burrowing animal, seldom occurring above ground except during the spring and fall. Encroachment by man into preferred habitat is the greatest threat to this species. In some instances, thermal stress caused by removal of overstory in sandhills communities have extirpated certain populations of this snake (Campbell, 1975).

The range of the short-tailed snake is confined entirely to peninsular Florida from Highlands to Columbia counties. This species occurs chiefly in longleaf pine/turkey oak associations and infrequently in upland oaks proximal to the former (Campbell, 1976). Two specimens were reported (Florida Game and Freshwater Fish Commission, 1976) to have been collected in sandpine and evergreen oak scrub. This is the first confirmed record of this species occurring in evergreen oak scrub. Longleaf pine-turkey oak ridges, upland hammock, and sand pine scrub are cited (Campbell, 1976 and Highton, 1956) as preferred habitat for this species; however, such forest associations are not found on the site.

The only confirmed record of this species in Citrus County is several miles to the east of the proposed site and in a more xeric habitat (Campbell, 1976).

Methods for collecting these animals include pit fall traps with diversionary drift fences, hop nets, and nocturnal road driving. Nocturnal road driving was the method employed to census this species. The short-tailed snake was not encountered on the site.

As with other secretive forms, the scarcity of information on the short-tailed snake makes it particularly difficult to assess impacts or to predict the occurrence of this species.

Methods

The objective of the field sampling was to verify the species occurrence on the site and to evaluate traces of land for their suitability as habitat for the various species. Before field sampling, a list of endangered species was prepared which included preferred habitats and other relevant parameters. Species listed by the United States Department of Interior as Rare and Endangered as well as the gopher tortoise and commensal organisms were the species of major concern. In regard to secretive forms of rare and endangerd fauna, it was determined that habitat association was the best means for predicting their occurrence on the site. Field sampling was conducted as discussed and approved in the plant of study.

Habitat evaluation was made in each major ecosystem based on various types of cover, availability of food, water sources, and denning sites or nesting areas. These parameters were determined from such factors as tree stand characteristics and species composition in both overstory and understory. Additional factors noted, included herbaceous ground cover, organic ground cover (leaf, logs, sticks, etc.), rock abundance, moisture conditions of the soil, and snags. Vegetative data were noted in field by the wildlife biologists and compared with data generated during the vegetative survey. Information was gathered by walking transects and recording habitat condition at an interval of 30 meters. The various systems were rated as good, average, or poor habitat in regard to a particular species. In addition to gathering data on ecological parameters, species of wildlife observed were also recorded. Searches for snakes and other secretive fauna were made while walking transects. This included investigation of wood piles, thickets, and other organic debris. The intent of this survey was to identify any of those sensitive species which might occur in these habitats, including the indigo snake.

In order to reevaluate the status of the indigo snake on the site, an additional survey was conducted specifically for this species. The survey consisted of searching those areas where indigo snakes or identifiable evidence were likely to occur. In moist habitats (mesic, hydric, and coastal hydric hammock) searches were concentrated in areas of dense understory and ground cover vegetation adjoined by clearings and grassy openings. Also investigated were stumps, logs, rock piles and burrows (pine flatwoods and evergreen oak scrub) gopher tortoise burrows were checked for evidence of indigo snakes. The areas surrounding these burrows were also surveyed.

Field Sampling

Field sampling began on the morning of August 22, 1977 and continued through the evening of August 26, 1977. The morning of each day was spent either setting or baiting traps for small mammals. Each day from approximately 1300 hours until 1500 hours qualitative random searches were employed in the most suitable habitat for gopher tortoise burrows. The afternoons, usually beginning around 1500 hours and lasting until dark, were used to walk transects recording both habitat conditions and species of wildlife. Two transects were inventoried daily beginning with number one on August 22, and ending with number six on August 24. Number seven transect was inventoried on August 25. Two night surveys were conducted by driving along unimproved dirt roads on the property. An additional investigation for the indigo snake was made on August 11, 1978.

Florida Manatee

A dialogue has been carried on with personnel of the Gainesville Field Station National Fish and Wildlife Lab concerning Manatee populations near the proposed site and the potential impacts of Units 4 and 5 upon the endangered Florida Manatee. Individuals at the Gainesville Fish and

Wildlife facility have been collecting data concerning the presence of manatee over a larger area which includes the power plant site. Available information is presently in two forms (Powell, 1978).

One source is a study which receives reports of manatee sightings from members of the general public. Anyone who has seen a manatee is asked to report the sighting by notices posted in appropriate areas. Information from these reports is collected by the Gainesville laboratory and is in the process of being computerized. At present, only the data from 1974 through 1976 has been computerized. Data are entered with a coordinate system which allows printouts of site specific information to be obtained (Scott, 1978).

Another source of information is from overflights of the discharge area which Fish and Wildlife personnel have undertaken on a biweekly basis as a part of a regular census of manatee population in the Crystal River area. Data from these studies have not been developed (Powell, 1978).

A printout of Citrus County sightings was obtained from the 1974 to 1976 data bank. Table 6.1-3 presents a list of sightings reported near the existing power plant facility. The reported years cover a period of time when numerous researchers from the University of Florida were at work in the estuary surrounding the power plant site. It is safe to assume the area was more extensively observed than many other comparable areas during the same period and that scientifically trained observers were more likely to file reports of the sightings than were members of the general public. In short, the number of sightings of manatee in the vicinity of the facility is believed to be a result of more extensive observation and reporting for this particular study rather than an indication of any concentration of manatee in the area.

As mentioned previously, the data from the aerial survey have not yet been compiled. Mr. Powell of U.S. Fish and Wildlife who has been conducting these studies indicated that his initial impression before

Table 6.1-3. Manatee Sightings Reported Near the Crystal River Site to U.S. Fish and Wildlife for 1974-1976

Month	Year	Down*	Across	Number	Respondent
March	1975	482	592	1	B. Obry
March	1975	482	592	1	S. Rednour
March	1975	482	592	2	M. Osterling
June	1975	480	599	1	M. Homer
February	1975	479	595	1	M. Homer
March	1975	479	595	2	M. Homer
August	1975	479	596	1	C. Taylor
June	1975	478	595	1	P. Purcell

* The site of the present Crystal River facilities is about 480 down and 590 across in the Fish and Wildlife computer mapping system. For purposes of comparison, it may be useful to note that the coordinates of the Crystal River head springs are 496 down, 571 across.

Source: U.S. Fish and Wildlife Services, 1978.

intensive study of the data indicated several trends. The manatee do not appear to be using the warm waters of the discharge in cold weather as extensively as has been observed at other sites. The nearby Crystal River spring waters have been reported to be a haven for the manatee (Hartman, 1971). It appears that the manatee are so strongly drawn to the ancestral meeting place at the Crystal River springs that they bypass the power plant discharge waters as a permanent residence. The researchers do feel that when the manatee are moving during fall and spring, they may use the discharge water as a temporary haven during sudden cold weather periods (Powell, 1978).

The Gainesville laboratory also collects the bodies of dead manatees which are found. No manatee bodies have been collected from the power plant area nor have any of the bodies found in the Citrus County area shown signs of power plant-related injuries (Scott, 1978).

6.1.4 GROUNDWATER

Descriptions of the ground water hydrology in the area were obtained from two reports. Geraghty and Miller's Evaluation of Groundwater Resources (1977) at the plant site provided a fairly comprehensive summary of previous groundwater investigations in the area. The other report (Faulkner, 1972) provided some extensive data concerning the geohydrology of the barge canal area. The data presented in this publication are not totally representative of the site and were not used extensively.

Data concerning rainfall in the vicinity of the site were obtained from the U.S. Department of Commerce (1975) from records kept at Inverness, Florida, 39 kilometers (24 miles) southeast of the proposed site.

6.1.5 AIR

The FPC Crystal River power plant is located in a rural area, isolated from other large point sources. Background values of sulfur dioxide, the major pollutant of electric generating plants, are assumed negligible in the vicinity of the site. No natural sources of sulfur dioxide that would constitute any appreciable concentration levels exist in the area.

Until recently, very little background information existed for total suspended particulate matter in this area. An ambient air sampling program for both sulfur dioxide and particulate matter around the site location has been operating since May 1977.

Ambient air quality data pertinent to the application are available from a four-station SO_2 and TSP ambient sampling network and are presented in Chapter 2. TSP is measured with Federal Reference Method (FRM) High-Volume samplers at each station. These monitors are operated on a once-every-sixth-day schedule, which corresponds with the schedule maintained by the regulatory agencies. Thermally-controlled FRM bubblers for sulfur dioxide are operated at two stations. The sulfur dioxide monitoring schedule also corresponds to that established by the regulatory agencies. FRM Equivalent Monitors are operated on a continuous basis at two stations. These monitors are Thermo Electron Model 43 with automatic zero and span. All calibrations are composed either with National Bureau of Standards or with a primary standard. Procedures for sampling are explained in the appendices.

Local meteorological data are acquired at the site by an instrumental two-level tower and were utilized in the Climatology section. Data on wind speed and direction at two levels, plus ambient temperature, lapse rate, precipitation, and barometric pressure are measured on strip charts, continuously, on or near the tower. The sensors are calibrated and maintained routinely in accordance with Atomic Energy Commission

Commission sensitivity specifications for "met" towers (Unit 3 at Crystal River is a nuclear unit). Additional information on the meteorological tower can be found in the appendices.

A 5-year meteorological record from Tampa, Florida, was used in the dispersion modeling. This information was reduced into both long-term and short-term modeling formats applicable to current EPA models.

Cloud cover and cloud ceiling data for the determination of Pasquill's stability classes were taken from the U.S. Weather Bureau office at Tampa. This office was the most representative location where 5 years of data are available. Cloud cover and ceiling are recorded each hour by a trained observer at the U.S. Weather Bureau office.

Three EPA-developed Guassian dispersion models were utilized for all modeling. The Air Quality Display model with Briggs plane rise equation was used for the annual estimates. Short-term impacts were estimated with the single source CRSTER model and multi-source Point Multiple model (PTMTP-W). These models are currently considered the "state-of-the-art" tools available for prediction of ambient air quality concentrations. A description of these models is contained in the appendices.

6.1.6 GEOLOGY

Geological data were obtained principally from four reports. The most useful of these was the Vernon (1951) study of geology in Citrus and Levy counties. The information contained in the Vernon report was obtained through logs of wells in the area as well as through air-photo analysis of surficial features. Most of the data is not specific to the study area, but to the region.

Other geologic information was obtained from the Geraghty and Miller (1977) report, the Department of the Army, Navy and Air Force Seismic Design Manual (1973), and Faulkner's (1973) study of geology in the Ocala, Florida, area. All of these reports supplied only general information. The Geraghty and Miller report provided information, based on existing well logs, on the stratigraphy of the study area. The Department of Army, Navy, and Air Force report provided the relative probability of earthquakes in the study area.

6.1.7 ARCHAEOLOGY

In 1972, the Department of State, Division of Archives, History and Record Management, Bureau of Historic Sites and Properties conducted an archeological and historical survey under contract with the Florida Power Corporation. Basically, the agreement provided for the employment of two survey archaeologists for a period of 2-1/2 months. They were to field-check completely all Florida Power property in the Crystal River tract and to devote any remaining time to surveying the areas within an 8-kilometer (5-mile) radius of the plant site. Florida Power provided survey vehicles (four-wheel drive truck and a boat), storage and office facilities, and logistical and interpretive assistance.

Prior to field examination, the Florida State Master Site Files, local histories, records, old maps, etc., were reviewed to ascertain whether anything of known historical importance was located on or within an 8-kilometer (5-mile) radius of the Crystal River tract. Only two sites were previously recorded in the area.

The survey focused on the coastline and associated estuarine and riverine drainage within the specified 8-kilometer (5-mile) radius. The survey area extended from a point south of the mouth of Crystal River, north to a point in Levy County north of the Withlacoochee River. Survey trips were made up Crystal River, Withlacoochee River, and several of the larger tidal drainages. Survey transportation was restricted to four-wheel drive and a boat. The surface surveys were accomplished by walking over those areas which were determined through the initial research to be the most likely locations of sites. Each site was recorded with the Florida Master Site File.

6.1.8 NOISE

The ambient noise baseline survey was conducted on October 18, 1977. Normally, in determining noise monitoring stations, the following selection criteria (Bolt, Beranek, and Newman, 1973) are employed:

1. Critical Noise Sensitive Sites (e.g., schools, hospitals, or churches on or near major thoroughfares);
2. Residential Areas; and
3. Remote Areas for "Noise Floor" (these should yield the lowest ambient noise level).

Within several kilometers of the existing and proposed plant sites, there are no areas fitting the first two categories. Noise floor levels are encountered between the plant and any noise-sensitive sites. Thus, the scope of the baseline study included only the plant site and its immediate vicinity.

Stations were chosen in order to ascertain noise levels on the present plant site, the future plant site, and at various distance from each. The objective of this study was to determine the "noise drop-off" characteristics from the present plant in order to gauge the future effects of the proposed facility.

A General Radio 1933 Precision Type noise monitor was used for execution of the monitoring survey. Each station was monitored one time while the plant was under normal operating conditions. Noise measurements were taken every ten seconds and recorded. After 50 readings were taken and recorded, a test was made to determine whether or not the quantity L_{10} could be estimated with 95 percent confidence within 2 dBA of the actual level. This test required that the first, fifth, and tenth highest readings be recorded in the same or in adjacent sound level categories.

If the criteria were not met, then 50 more measurements were made and the criteria were applied to the fifth, tenth, and seventeenth highest readings.

6.2 PLANT CONSTRUCTION AND OPERATION MONITORING

During site preparation, facility construction, and facility operation; the environmental parameters of air and water will be monitored for levels relative to those projected in Chapters 4 and 5. In addition, a plan of action will be implemented if an archaeological discovery is made.

The impacts related to the other environmental areas; i.e., aquatic and terrestrial ecology, geology, solid wastes, and noise, will not be of significant magnitude to warrant additional monitoring during these phases of the project.

6.2.1 AIR

During site preparation and facility construction, the significant air emissions will be fugitive dust from land clearing and grading and smoke from burning of the land-clearing wastes. Both of these emissions are classified as particulate matter and can be measured by the Federal Reference Method (FRM) High-Volume samplers (40 CFR Part 50).

Once Units 4 and 5 are operating, the significant air emissions to be monitored will be the particulate matter and sulfur dioxide from the combustion of coal in the two coal-fired steam-generators. In addition to the FRM High-Volume sampling technique for sampling particulate matter, an FRM sulfur dioxide reference method and equivalent methods for sulfur dioxide have been promulgated. Both methods can be utilized to measure the air emissions during plant operations.

Three sampling stations are proposed as the construction and operation air monitoring network. These stations are the same as three of the baseline monitoring program stations (stations 1, 2, and 4; station 3 will not be continued; see Figure 2.9-1). Each station will measure ambient concentrations of total suspended particulate matter and sulfur dioxide (sulfur dioxide monitoring will be required only during operation). A minimum sampling will be scheduled once every sixth day, and monitoring will continue for the life of the units.

The meteorological monitoring data available from the existing meteorological station will continue to be used by Florida Power. The tower will monitor those parameters stated in Section 6.1.5.

6.2.2 WASTEWATER

The water quality monitoring program will consist of sampling at the following six potential discharge sources during plant operation:

#009 and 010	Cooling Tower Blowdown
#011	New Coal Storage Area
#012	Ash Disposal Area
#013	Runoff Collection Retention System

All sampling and analytical procedures will be those contained in 40 CFR 136.

The cooling tower blowdown will be discharged to the existing discharge canal as shown in Figure 6.2-1. The wastewater will contain chlorine and phosphate as algicide and scale inhibitors and will concentrate the solids content of the cooling water. Prior to mixing with the cooling canal water, the discharge will be sampled for the following parameters at the frequency indicated:

pH—Once per day
Flow—Continuous
Temperature--Continuous
Chlorine Residuals (Free and Total)--Once per week including time of release
Phosphorus (as P)--Once per week
Calcium--Once per week
Conductivity—Continuous

The wastewater from miscellaneous plant drains, steam condensate feed cycle, and the neutralization basin will be collected in the plant drains collection pond. The pond is designed for evaporation and percolation of all incident rainfall and influent wastewater except for a relatively small volume which will be routed to the ash disposal area for ash dust suppression and compaction; thus, it is not necessary to equip the pond with a design storm overflow structure.

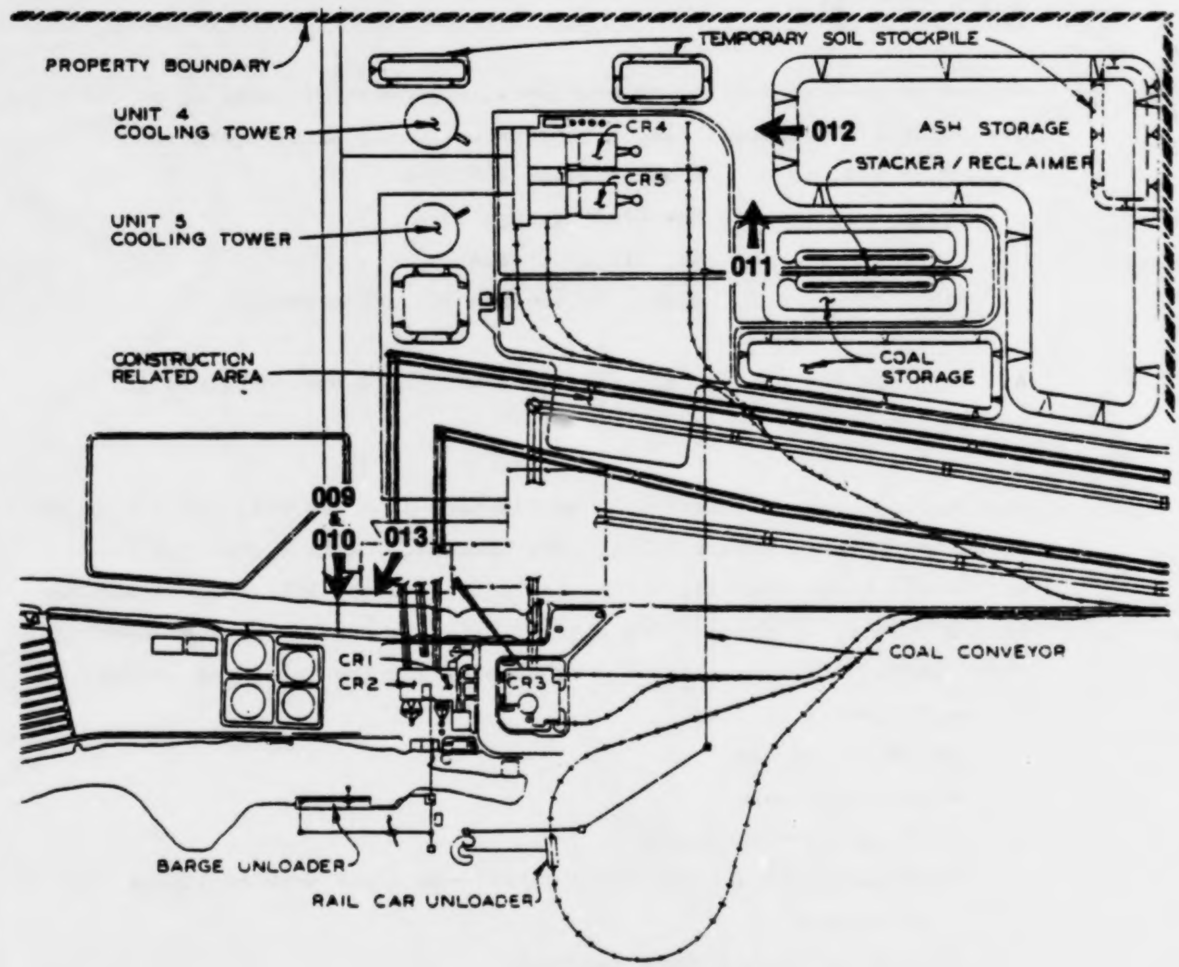

Figure 6.2-1
EFFLUENT SAMPLING LOCATIONS.

N

0 1000 2000
SCALE IN FEET

SOURCE: BLACK AND VEATCH, 1980.

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The new coal storage area will be diked to retain runoff equivalent to a quantity of rainfall equal to or less than a 10-year, 24-hour storm. Runoff in excess of this design criteria will discharge into the runoff collection ditch which flows into the cooling water discharge canal. The standing water in the areas or the discharge when it occurs will be sampled for the following parameters at the frequency indicated:

Flow--Weir reading once per week during discharge periods
Total suspended solids--Once per week
Heavy metals (cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, and zinc) and arsenic--Once per month during periods of discharge; otherwise, samples will be taken from the pond once in the 3-month monitoring period.

The ash disposal area will be a diked storage area with sufficient capacity to retain the direct runoff from a storm equal to or less than a 10-year, 24-hour storm event. Runoff in excess of this design criteria will be discharged to the canal retention system and then into the existing cooling water discharge canal. The diked area or its discharge will be sampled for the following parameters at the frequency indicated:

Flow--Weir reading once per week during discharge periods
Total suspended solids--Once per week
Heavy metals (cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, and zinc) and arsenic--Once per month during periods of discharge; otherwise, samples will be taken from the pond once in the 3-month monitoring period.

The canal retention system will receive discharges from the plant roof drains, and runoff from the ash disposal area and the coal storage areas which exceed the design criteria of those areas. In addition, the canal retention system will receive the general stormwater runoff from the remaining facility areas and will have a capacity to store the runoff from rainfall events equal to or less than a 10-year, 24-hour storm.

The water in the ditch or the discharge when it occurs will be monitored for the following parameters:

pH—Once per day

Flow—Weir reading once per day during discharge periods

Total suspended solids--Twice per week

Oil and grease--Once per week

Heavy metals (cadmium, copper, iron, lead, mercury, nickel, selenium, and zinc) and arsenic—Once per month during periods of discharge; otherwise, samples will be taken from the pond once within the 3-month monitoring period.

Disinfected sewage treatment plant effluent will be routed to a dedicated percolation pond, sized to allow percolation of the entire effluent flow.

6.2.3 GROUND WATER

Groundwater monitoring is incorporated into a leachate monitoring and testing program designed to comply with requirements of the FDER Special Conditions of Certification, as revised in September 1978, and the requirements of the EPA Environmental Impact Statement and NPDES permit for Crystal River Units 4 and 5. Although it is specifically concerned with leachate from the ash landfill, the program will effectively monitor shallow ground water throughout the project site. The program, to be conducted by Environmental Science and Engineering, Inc., consists of the following major phases:

- Phase I--Baseline Monitoring, Groundwater Quality and Hydraulics
- Phase II--Leachate Formation and Control, and Attenuation Testing
- Phase III--Zone-of-Discharge Analysis
- Phase IV--Evaluation of Performance of Demonstration Landfill Cells
- Phase V--Geophysical Survey and Mapping of Solution Cavities
- Phase VI--Design and Construction of Ash Landfill

PHASE I: BASELINE MONITORING

This phase includes a year-long water quality study with provisions for subsequent annual sampling, as well as an analysis of aquifer hydraulics.

A network of 15 observation wells, 12 shallow and 3 deep, has been constructed onsite as shown in Figure 6.2-2. Table 6.2-1 provides well construction data. The wells are located both upgradient and downgradient of the ash disposal area, new coal storage area, plant drains collection pond, and runoff retention system.

Key water quality parameters will be monitored monthly and extended water quality parameters will be monitored quarterly as indicated in

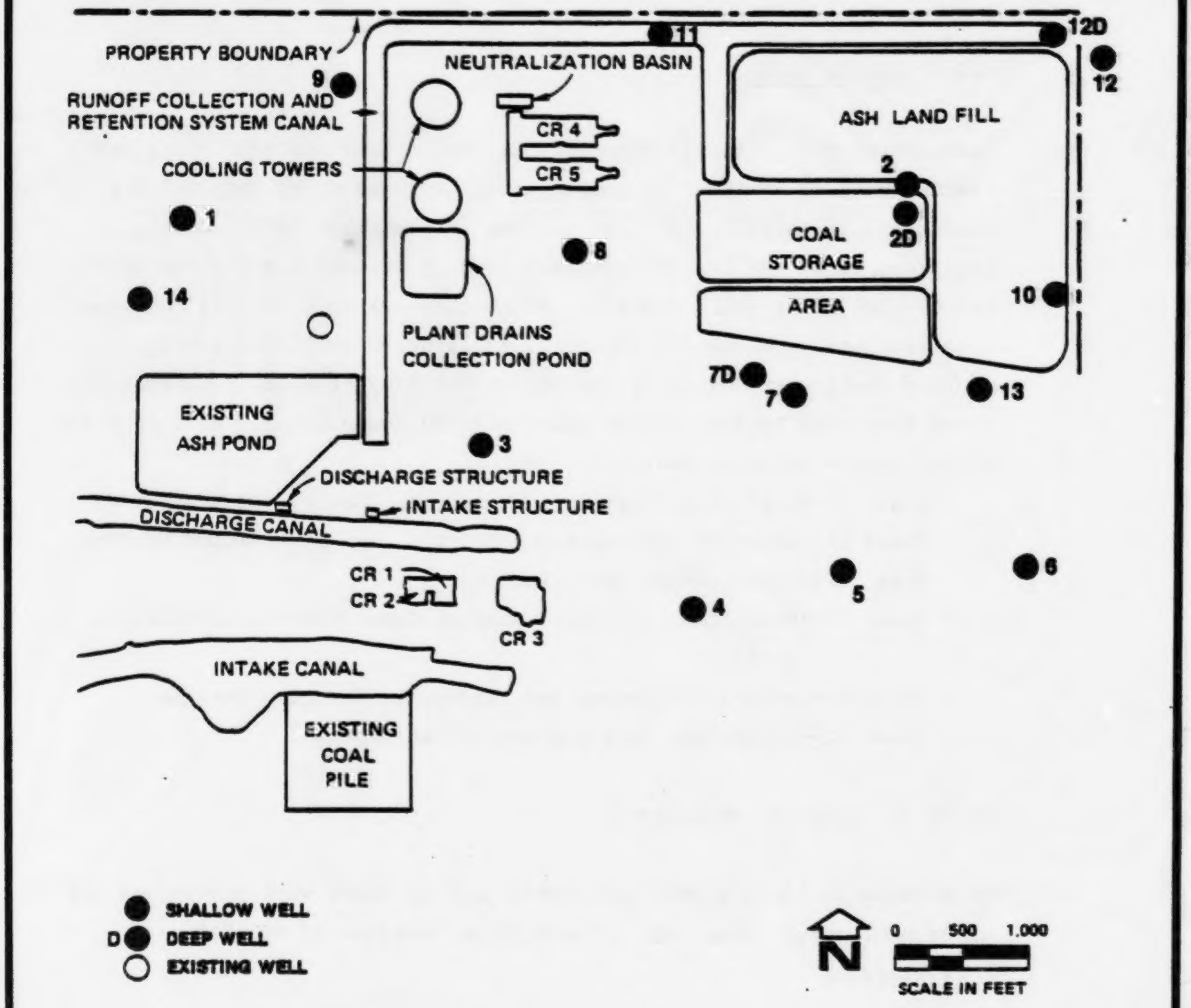

Figure 6.2-2
LOCATION OF OBSERVATION WELLS FOR LEACHATE MONITORING PROGRAM FOR CRYSTAL RIVER UNITS 4 AND 5.

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1980.

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PROPOSED
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Table 6.2-1 Construction Details of Observation Wells for Leachate Monitoring Program for Crystal River Units 4 and 5

Well Number*	Well Diameter	Well Depth	Casing Depth
OW-1	2"	20'	18.5'
OW-2	4"	20'	18.5'
OW-2D	2"	58'	53.8'
OW-3	4"	20'	18.5'
OW-4	2"	23'	23.0'
OW-5	2"	20'	18.5'
OW-6	2"	20'	18.5'
OW-7	4"	20'	18.5'
OW-7D	4 1/2"†	45'	42.4'
OW-8	2'	20'	18.5'
OW-9	2"	20'	18.5'
OW-10	2"	20'	18.5'
OW-11	2"	20'	18.5'
OW-12	4"	20'	18.5'
OW-12D	2"	53'	47.3'
OW-13	2"	20'	18.5'
OW-14	2"	20'	18.5'
OW-15	4"	20'	18.5'

*See Figure 6.2-2 for location.
†Upper 17.4' of hole has 4" casing; 2" casing from 17.4' to bottom of hole.

Table 6.2-2. Wells 7, 7D, 12, and 12D will be sampled in the water quality study.

Hydraulic aquifer analysis will be based on wet and dry season monitoring of observation wells for water level and specific conductivity, and on tide data, barometric pressure, pan evaporation, and rainfall. Data will be used to construct water table elevation maps, to assess hydraulic homogeneity in the shallow aquifer, to determine the degree of tidal coupling between the aquifer and the Gulf of Mexico, and to establish aquifer response to rainfall.

PHASE II: LEACHATE TESTING

This phase will consist of the following five related efforts:

Ash shake tests will generate a synthetic leachate from ash representative of that to be produced at Units 4 and 5. Actual leachate characteristics may be predicted using the synthetic leachate.

Soils testing will utilize limestone fill base and subsoil from the ash landfill site to establish baseline metals concentrations and to determine the ability of the subsoil to remove metals from leachate.

Clay testing will be performed on locally available clays to determine their suitability for use as liners for the ash landfill.

Permeability and compaction testing of ash, subsoil, and clay potentially suitable as liners will be analyzed to establish the compaction and mixtures necessary for suitable permeabilities.

Column leaching tests will assess leachate attenuation through columns of potential liner materials.

Table 6.2-2 Groundwater Quality Parameters

Key Water Quality Indicators (Monthly)

Specific Conductivity*
Color
Turbidity
Chloride
Sulfate
Dissolved Organic Carbon
Total Dissolved Solids
Total Suspended Solids
Iron
Nickel
Selenium
Chromium
Arsenic
Beryllium
Mercury
Lead

Monitored During Aquifer Analysis

pH
Redox Potential
Specific Conductivity*
Dissolved Oxygen
Temperature

Extended Water Quality Indicators (Quarterly)

The key indicators listed above plus:

Aluminum
Barium
Calcium
Magnesium
Sodium
Cobalt
Gross Alpha†
Vanadium
Molybdenum

---

*Monitored in all wells during aquifer analysis; monthly water quality program monitors specific conductivity in only four wells.

†If Gross Alpha $\geq$ 15 pic/l, the following elements will be analyzed:
Radium 226
Uranium
Thorium

PHASE III: ZONE OF DISCHARGE ANALYSIS

The results of Phase I and Phase II will be analyzed in this phase through groundwater quality modeling in order to simulate leachate transport through the aquifer zone of discharge.

PHASE IV: DEMONSTRATION CELLS

One or more test cells designed to minimize leachate production will be constructed at the ash landfill site, using representative ash. Seepage through the cell will be monitored in adjacent wells constructed especially for this purpose.

PHASE V: GEOPHYSICAL SURVEY

Resistivity analysis will provide information on the presence of solution cavities within the landfill.

PHASE VI: DESIGN AND CONSTRUCTION OF LANDFILL

Preceding phases having provided the site- and material-specific information necessary, an ash landfill will be designed and constructed which will enable adequate leachate attenuation.

6.2.4 ARCHAEOLOGY

During construction activities, normal archaeological monitoring and safeguards will be followed to protect possible discoveries. The state historic preservation officer will be notified if a potential historical site or find is discovered. Work will be stopped in the immediate area and will not be resumed until the approval of the Florida Division of Archives, History, and Records Management is received.

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7.0 ECONOMIC AND SOCIAL EFFECTS OF PLANT CONSTRUCTION AND OPERATION

7.1 INTRODUCTION

Formal cost-benefit analysis procedures were originally developed as a means of evaluating alternative public projects. Benefits to the public were expressed in monetary terms so that the ratio of benefits to expenditures for a given project could serve as a general index of project favorability. The cost-benefit ratio thus provided a common measure for evaluating dissimilar uses of public funds. Recently, cost-benefit analysis has also become widely accepted for project justification in the private sector and joint public/private ventures.

The proposed construction and operation of Crystal River Units 4 and 5 have elements of both a public and private enterprise because of Florida Power's status as a publicly-regulated utility and the public's critical need for electric power. The application of cost-benefit analysis in this case is complicated by the large number of different population groups and organizations that will experience benefits and costs as a result of the project. A partial listing of these groups is as follows:

Florida Power, its employees, and stockholders
Local government units and taxpayers
Residents and businesses in the Florida Power economic impact area
Workers in the Florida Power labor market area
Employers in the Florida Power labor market area
Existing and prospective customers of Florida Power
State government of Florida
Competing fuel users in the United States and elsewhere

Due to the number of groups and interrelationships involved, the full economic impacts of the project could not be expressed adequately in a single cost-benefit comparison or ratio. Two other problems affecting the analysis are the following. First, most of the dollar flows generated by the proposed project will be payments for goods or services rendered, so that the actual net benefit created in each case will not equal the amount of the transaction per se. The net benefit will consist either of a portion of the payment, or a "surplus" quantity which is not actually paid (see below). Second, there are a large number of unknown factors which make the forecasting of future costs and benefits difficult.

This chapter will focus first upon the cost-benefit status of the project for Florida Power itself, and for the individuals and organizations that purchase electricity from Florida Power. Other economic and social impacts of the project will be listed and discussed individually, without attempting to determine whether the sum of benefits will exceed the sum of costs for specific population groups or organizations. Even in the two cases just mentioned, it will be possible only to state whether or not there is a net benefit under various alternative assumptions.

NOTE: The Draft Environmental Impact Statement was prepared in 1977 and 1978. Since that time, a number of changes have occurred, such as the dramatic increase in the price of energy and in discount rates. Although updated economics data would reflect different statistics, the conclusions presented in this chapter would not be changed, since the analysis performed in 1977 and 1978 compared costs/benefits on the same relative (present worth) basis.

7.2 COSTS AND BENEFITS OF THE PROJECT TO POWER USERS AND TO FLORIDA POWER CORPORATION

7.2.1 COSTS ATTRIBUTABLE TO PROPOSED CRYSTAL RIVER UNITS 4 AND 5

The cost-benefit analysis of the proposed project utilizes cost information that was originally developed to evaluate the choice between low-sulfur and high-sulfur coal (see Chapter 8). The annual costs of capital, fuel, and operation/maintenance have been determined for Crystal River Units 4 and 5 in each year of operation. The cost estimates assume the use of saltwater cooling towers. The present worth of these power generation costs for each unit has been determined by discounting back to April 1, 1978, using the estimated cost of capital to Florida Power (11.1 percent). The figures for the low-sulfur coal option, which is the only relevant case here, are shown in the upper portion of Table 7.2-1.

The assumptions underlying the estimated power generation costs are discussed in Chapter 8. Two especially significant quantities are the rates of escalation in fuel costs and operation/maintenance costs. The delivered cost of coal is assumed to rise by 10 percent per year between 1977 and 1980, and by 5 percent per year after 1980. Operation/maintenance costs are assumed to escalate indefinitely at a rate of 6 percent per year. Thus, the estimated power generation costs assume continued inflation in the U.S. economy. This point becomes important when placing a dollar value on the electricity produced.

The total costs attributable to the construction and operation of Crystal River Units 4 and 5 include a number of elements other than power generation expenditures. It is necessary to account for the costs of transmitting and distributing the electricity generated, plus the general administrative expenses and tax payments incurred by Florida Power. In addition, the proposed power generation units must contribute to the net income available for dividend payments to Florida Power stockholders. The information utilized to estimate these additional costs is presented in Table 7.2-2.

Table 7.2-1. Summary of Incremental Costs Associated with Crystal River Units 4 and 5

	Present Worth of Expenditures in Millions of April 1978 Dollars		
	Unit 4	Unit 5	Total
POWER GENERATION COSTS			
Capital	292.8	191.6	484.4
Fuel	700.5	644.0	1,344.5
Operation/Maintenance***	54.8	51.0	105.8
SUBTOTAL	(1,048.1)	(886.6)	(1,934.7)
SHARES OF OTHER COSTS ATTRIBUTABLE TO UNITS 4 AND 5			
Transmission, Distribution, and Administration*	87.8	80.8	168.6
Capital Costs Other than Power Generation Facilities †	20.4	13.4	33.8
Taxes Payable Currently**	129.4	119.1	248.5
Dividend Payments ††	110.3	101.5	211.8
SUBTOTAL	(347.9)	(314.8)	(662.7)
TOTAL PRESENT WORTH	1,396.0	1,201.4	2,597.4

* Assumed equal to 11.63 percent of fuel plus O/M costs.

† Assumed equal to 7 percent of capital costs for power generation.

** Assumed equal to 17.13 percent of fuel plus O/M costs.

†† Assumed equal to 14.60 percent of fuel plus O/M costs.

*** Operation/maintenance costs do not include contingencies associated with the operation of saltwater cooling towers; only normal costs are included.

Sources: Florida Power Corporation, 1978.
Environmental Science and Engineering, Inc., 1978.

Table 7.2-2. Recent Revenue and Expenses of Florida Power Corporation (x $1,000.00)

	1977	1976
SUMMARY OF REVENUES AND EXPENSES		
Production and maintenance expenses	317,218	305,329
Transmission, distribution, administration	38,789	33,635
Taxes payable currently	79,876	27,730
Deferred income taxes and investment tax credit (net)*	41,045	53,895
Depreciation*	54,440	41,440
Operating income	124,770	89,410
(Dividend payments)	(46,830)	(44,117)
(Net interest payments)	(49,093)	(42,722)
(Retained earnings)*	(28,847)	(2,571)
TOTAL OPERATING REVENUE	656,138	551,439
SELECTED EXPENSES AS PERCENTAGES OF PRODUCTION AND MAINTENANCE COST		
Transmission, distribution, administration	12.23%	11.02%
Taxes payable currently	25.18%	9.08%
Dividend payments	14.76%	14.45%
TOTAL	52.17%	34.55%

* These items constitute sources of funds used for construction. The figures for retained earnings do not include income other than operating revenues.

Source: Ten Year Statistical Report, 1976-1977; Florida Power Corporation.
Environmental Science and Engineering, Inc., 1978.

Table 7.2-2 presents a summary of revenue and expense statistics for Florida Power in 1977 and 1976. The portions of operating income devoted to dividend payments, net interest payments, and retained earnings are indicated by the figures in parentheses. The procedure used in assigning non-production costs to the proposed Crystal River units is to express the actual costs for 1977 and 1976 as percentages of production and maintenance costs, and then to apply the percentages to the future production costs for the proposed units. For example, the total cost of power transmission, distribution, and administration was equal to 12.23 percent of production and maintenance cost in 1977, and 11.02 percent in 1976 (see the lower portion of Table 7.2-2). The average of these two figures, 11.625 percent, can be applied to the sum of fuel and operation/maintenance costs for the proposed units to estimate the share of future transmission, distribution, and administrative costs attributable to these units. The present worth of each of these additional cost elements is listed in the lower portion of Table 7.2-1.

The additional cost elements shown in the lower portion of Table 7.2-1 do not include interest payments or funds used for new construction (indicated by asterisks in Table 7.2-2), since these items are already covered by the capital costs listed elsewhere in Table 7.2-1. However, estimates are included for capital costs other than power generation facilities. The shares of these costs attributable to the proposed Crystal River Units 4 and 5 are assumed to equal 7 percent of the capital costs for power generation.

The outcome of these computations is that the total present worth of expenditures associated with construction and operation of the proposed units is estimated at $2,597 million in April 1978 dollars (shown in the bottom line of Table 7-2.1). The present worth of Unit 4, at approximately $1.4 billion, is substantially above the worth of $1.2 billion assigned to Unit 5. The difference is due to sharing of facilities with Unit 4 and to the fact that costs occur later for Unit 5 than for Unit 4. These present worth values are intended to cover all costs attributable to the proposed Crystal River Units 4 and 5, including the normal profits required to keep a private corporation such as Florida Power in operation.

7.2.2 BENEFITS OF THE PROJECT TO FLORIDA POWER CORPORATION

The sale of electricity produces benefits for both Florida Power and its customers. Benefits to Florida Power can be estimated in a more straightforward fashion than benefits to consumers and thus are considered first. A major complicating factor is the difficulty of forecasting accurately forecasting the future price of electricity. All computations of future benefits are very sensitive to the price assumed (referring to the weighted average charge per kilowatt-hour for all classes of power users). Therefore, it is necessary to consider several different price escalation rates in the analysis.

The benefits of the proposed project to Florida Power consist simply of the revenues yielded by sale of electricity from Crystal River Units 4 and 5. Table 7.2-3 presents operating statistics for Florida Power which have been used to compute the average price of electricity in 1977. Total operating revenues in that year were equal to 4.12 cents per kilowatt-hour of electricity sold, but only 3.83 cents per kilowatt-hour generated, purchased, or interchanged (the difference due to company use and losses of energy). The latter type of figure is appropriate for valuing the net output of a new generating facility.

Regarding the escalation of electricity prices over time, four separate cases have been considered as shown in Table 7.2-4. The first three cases involve constant escalation rates of 4 percent, 4.5 percent, and 5 percent, respectively, for all years subsequent to 1977. The fourth case involves an escalation rate of 6.7 percent until July 1, 1980, and 4 percent thereafter. The fourth case is intended to be consistent with recent trends in electric rates, and with the assumed escalation in fuel cost. Between 1975 and 1977, the average price of electricity sold by Florida Power increased at a rate of 6.7 percent per year. The cost analysis has assumed that the delivered cost of coal to Florida Power will increase by 10 percent per year until 1980. Thus, a continuation of the 6.7 percent rate of increase in electricity prices during 1977 to

Table 7.2-3. Selected Operating Statistics for Florida Power Corporation

Total energy generated, purchased, and interchanged	17,133.8 Gwh
Company use and losses	1,198.8 Gwh
Total energy sold	15,935.0 Gwh
Total operating revenues	$656,138,000
Revenue per kwh sold	$0.0412
Revenue per kwh generated, purchased, and interchanged	$0.0383

Source: Ten Year Statistical Report, 1976-1977; Florida Power Corporation.

Table 7.2-4. Assumed Escalation Rates of Quantities Used in the Cost-Benefit Computations

Average Price of Electricity:	
Case I	4%
Case II	4.5%
Case III	5%
Case IV	6.7% before 1980 4% after 1980
Operation and Maintenance	6%
Fuel	10% before 1980 5% after 1980

Source: Environmental Science and Engineering, Inc., 1978.

1980 would imply that not all of the fuel cost increment will be passed on to Florida Power consumers.

Each of the proposed units is expected to generate an average of 3,300 Gwh of electricity per year over its 30-year active life. (Utilization of the full 640-Mw net capacity would imply power generation at a rate of 5,610 Gwh per year.) Using each of the four escalation rates listed in Table 7.2-4, the average price of electric power has been determined for every year between 1982 and 2013, based on a 1977 price of $0.0383 per kwh generated. These future prices have been multipled by 3,300 Gwh, discounted back to April 1, 1978 (using the cost of capital as the discount rate), and summed to yield a present value of electricity sales in millions of dollars. The resulting figures for each power generation unit, given each rate of price escalation, are presented in the first two columns of Table 7.2-5.

The total present worth of electricity sales in each case is presented in the third column of Table 7.2-5. The fourth column gives the present worth of project cost (from Table 7.2-1), which is the same for all four cases. The ratio of sales to cost is presented in the last column of Table 7.2-5. This ratio indicates the benefit-cost status of the project to Florida Power as a corporate entity (but not necessarily to its employees, customers, stockholders, etc.). A ratio of unity would mean that all project costs would be covered by revenues over the long run, including a reasonable return to investors. If Florida Power were a typical profit-making enterprise, a ratio greater than unity would mean that the project could be expected to yield excess profits. However, given that the company is a regulated public utility (and that any future electricity prices will be regulated prices), a value greater than unity probably indicates that the proposed project would be subsidizing other, less efficient power generation units.

The last column of Table 7.2-5 shows that the benefit-cost ratio of the project for Florida Power will be almost exactly unity in two different scenarios: (1) if electricity prices escalate at a uniform rate of 4.5

Table 7.2-5. Present Worth of Electricity Sales and Florida Power Corporation Expenditures Attributable to Crystal River Units 4 and 5

Assumed Rate of Escalation in the Average Sale Price of Electricity per kwh		Present Worth of Sales, in Millions of April, 1978 Dollars			Present Worth of Expenditures (Millions of Dollars) April, 1978	Sales/ Expenditures Ratio
		Unit 4	Unit 5	Total		
Case I:	4% per year	$1,262.1	$1,143.1	$2,405.2	$2,597.4	0.93
Case II:	4.5% per year	$1,361.0	$1,241.6	$2,602.6	$2,597.4	1.00
Case III:	5% per year	$1,469.7	$1,350.4	$2,820.1	$2,597.4	1.09
Case IV:	6.7% until 1980 4% after 1980	$1,362.3	$1,233.8	$2,596.1	$2,597.4	1.00

Source: Environmental Science and Engineering, Inc, 1978.

percent per year; or (2) if the price escalation rate is 6.7 percent until 1980 and 4 percent per year thereafter. A price escalation rate of 5 percent will yield a benefit-cost ratio of 1.086, whereas the ratio will be only 0.926 if electricity prices escalate at 4 percent per year.

According to these figures, it will not be necessary for Florida Power to pass on the full increases in fuel cost and operation/maintenance cost to consumers in order to break even on the proposed units. The two scenarios with benefit-cost ratios near unity would involve less rapid escalation in electricity prices than in fuel and operation/maintenance costs (except that the operation/maintenance escalation rate would be exceeded slightly during 1977-1980 in Case IV). On one hand, this means that the gain in average productive efficiency resulting from the introduction of Crystal River Units 4 and 5 could enable Florida Power to absorb certain cost increases internally. On the other hand, if the escalation in electricity prices is greater than the rates assumed in Cases II and IV, the analysis indicates that Crystal River Units 4 and 5 will be generating net revenue in excess of normal profits. Because of the status of Florida Power as a publicly regulated utility, this revenue must ultimately benefit the public. For example, it could be applied to upgrading or pollution control measures at other facilities in the system.

7.2.3 NET BENEFITS TO ELECTRICITY CONSUMERS

The benefits of the proposed Crystal River Units 4 and 5 to Florida Power customers will involve the influence of the project on the average price of electricity and the availability of electric power. The second factor relates to the ability of Florida Power to meet peak power demands without costly interruptions in service. The manner in which these factors determine consumer benefit is illustrated below in a brief supply-demand analysis. The analysis is complicated somewhat by special circumstances involving electric power production (namely, the importance of peak versus average demands, the existence of regulated prices and non-price rationing, and the costs of service interruption). However, it is possible to represent the essential elements.

Figure 7.2-1 depicts three hypothetical cases of supply-demand equilibrium for electric power. Considering Case I, in the upper diagram, the demand curve is denoted DD and the supply curve is denoted SS. (Ignore for the moment the dashed-line extension of the supply curve.) Since Florida Power is a regulated public utility, the supply curve is equivalent to an average cost curve. That is, the analysis assumes that at any level of production, the average price charged for electricity will never exceed the level necessary to cover all costs (including a normal return to investors). The downward slope of the curve at low levels of production reflects the influence of fixed costs; the upward slope in the high output range reflects the need to utilize relatively inefficient equipment when production approaches capacity. (The supply curve shown pertains to an intermediate time horizon. In the very short run, the supply function would be horizontal since electric rates would be fixed. In the long run, the supply function would also be nearly horizontal, since the company could adjust its productive capacity to any level that was optimal in terms of demand.)

The intersection of the supply and demand curves for electric power in Case I occurs at point "A." The equilibrium output is thus the quantity Q_1 (in Kwh). The total expenditures for electricity by all classes

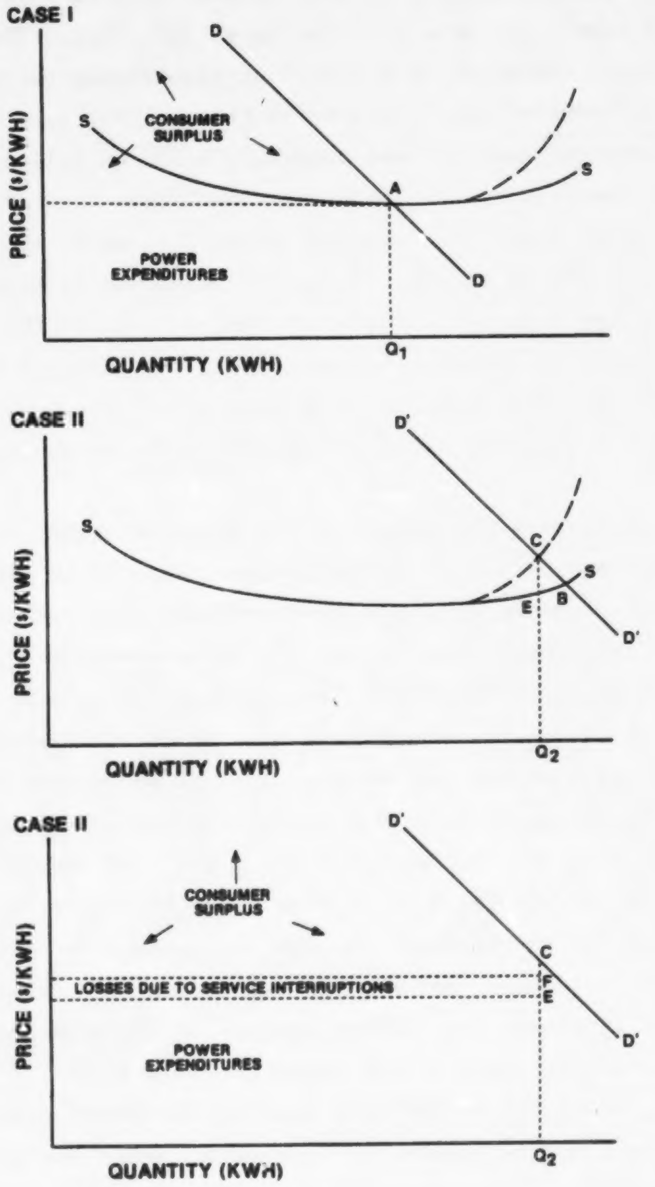

Figure 7.2-1
GENERALIZED SUPPLY-DEMAND EQUILIBRIUM FOR ELECTRIC POWER

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978

FLORIDA POWER CORPORATION

PROPOSED
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of users are represented by the rectangular area below and to the left of "A," namely the area enclosed by dotted lines. The net benefits accruing to customers as a result of electricity purchases can be measured in terms of the "consumer surplus." This quantity is the sum of all additional amounts that consumers would be willing to pay if each unit of electricity were sold individually at the maximum price that the market would bear. The consumer surplus is equal to the area above the horizontal dotted line but below the demand curve (not all of which is shown in the diagram). Since consumer surplus is the best measure of net benefits to electricity purchasers, the relevant question when considering a new facility is whether or not the facility will cause an increase in consumer surplus relative to the no-project alternative.

Before discussing the impact of the proposed units, it is necessary to describe another set of circumstances. Case II in Figure 7.2-1 depicts a future situation in which the demand for electric power has increased, so that the demand curve is now the line denoted D'D'. If this demand function referred to constant rather than fluctuating energy requirements, the equilibrium would occur at point B. However, it is assumed in this example that the average level of production implied by point B would involve short-term peak energy consumption exceeding the productive capacity of the power company. Thus, the average or long-term production of electricity is constrained to a lower quantity, denoted Q_2. In order to represent this as an equilibrium situation, another "supply curve" has been drawn in the figure as a dashed line. This function expresses the limited ability of the power company to fulfill short-term peak demands. The equilibrium solution is shown to occur at point C, where the dashed line crosses the demand curve. The dashed line is not a true supply curve, however, since the price paid by power customers is that indicated by point E rather than point C. (This is a case of non-price rationing which results because the producer is restricted to the average cost curve when setting prices, rather than charging what the market will bear.)

The lower portion of Figure 7.2-1 depicts the net benefit to consumers associated with the situation just described. Payments to the power company are equal to the area below the horizontal dotted line through point E. Consumer surplus would equal the area above this line. However, the present example assumes that power customers suffer economic losses as a result of the capacity constraint on peak energy usage (e.g., monetary costs associated with power failures). These losses are represented in the diagram as a subtraction from consumer surplus. The magnitude of the subtraction is equal to O_2 times the distance between points F and E. (The placement of point F is not related to the other curves; F could be either above or below point C.) Case II is very important in the present context since capacity constraints could well affect future sales by Florida Power if the proposed facilities are not constructed.

Figure 7.2-2 deals with the effect on consumer surplus of an increase in power generating capacity. In both of the cases depicted, the supply curve without new facilities is denoted SS, whereas the supply function with the addition of new capacity is denoted S'S'. The two cases illustrate the conditions under which consumer surplus is increased by the expansion of generation capacity. In case A, the supply-demand equilibrium without new facilities occurs below the level at which capacity is constraining upon electricity sales. (The equilibrium point G lies to the left of the dashed line.) Thus, the special circumstances involving capacity constraints do not apply either before or after the addition of new facilities. In this case, it is obvious that consumer surplus will increase only if the new facilities reduce the average price of electricity. That is, since the demand curve is unchanged, the area between the horizontal price line and the demand curve can only increase if the price line is lowered. This situation is shown to occur in case A, where the supply-demand equilibrium shifts from point G to point H.

Case B in Figure 7.2-2 is a situation in which capacity constraints are binding before the addition of new facilities. The demand curve and the points C, E, and F are all at the same locations as in Case II of Figure 7.2-1. As before, point F refers to the "price" of power when losses due to service interruptions are added to the actual payments for electricity. This case is assumed to be a situation in which the new production facilities are somewhat less efficient than the existing

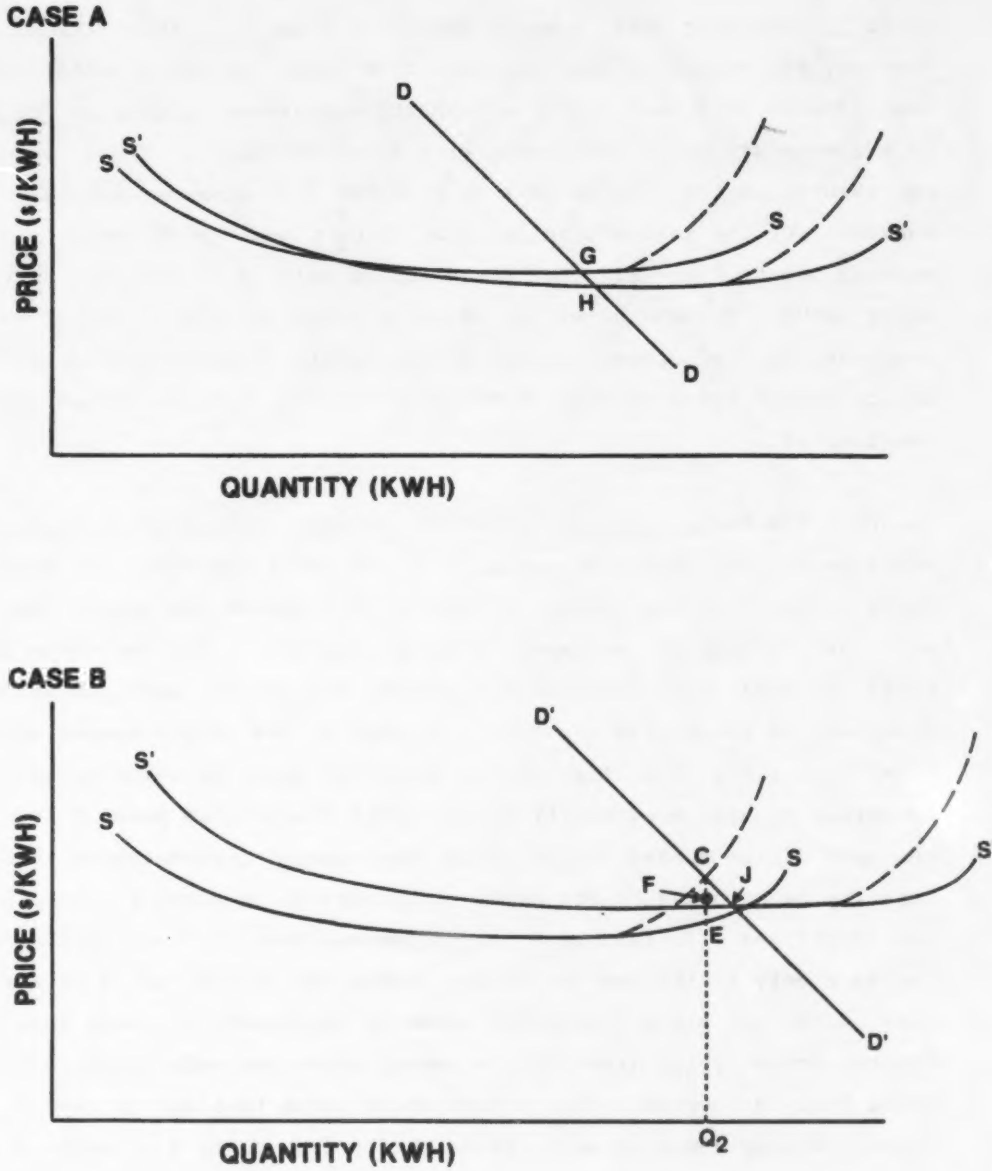

Figure 7.2-2
HYPOTHETICAL EFFECTS OF INCREASES
IN PRODUCTIVE CAPACITY

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

facilities. Thus, the new supply curve S'S' lies above the old supply curve SS throughout the relevant range. The new supply-demand equilibrium is at point J, which involves an increase in direct payments for electricity (relative to point E). Nevertheless, there is an increase in consumer surplus as presently defined, for the reason that losses due to service interruptions are eliminated. The two important considerations are that there is no capacity constraint at point J, and that the new supply curve S'S' lies below point F. The increase in consumer surplus is equal to O_2 times the ordinate of F minus the ordinate of J, plus the small triangular area to the right of F. This example demonstrates that electric power consumers can benefit from new productive capacity when there is no change, or even a moderate decline, in the overall efficiency of production.

Now referring specifically to Florida Power, it is difficult to establish with certainty that the proposed Crystal River Units 4 and 5 will increase the overall productive efficiency of the system. Such an increase appears very likely, in view of the previously-discussed assumption that Florida Power will not have to pass on to consumers the full escalation in fuel and operation/maintenance costs in order to break even on these new units. In any case, the examples just cited show that consumers can benefit significantly even if there is not an increase in efficiency that translates into lower prices. The magnitude of the net benefit will depend upon the extent to which there would be a capacity constraint without the proposed units, and upon the monetary losses that would result from service interruptions.

In the absence of Crystal River Units 4 and 5, the loss of load probability (LOLP) for the Florida Power system would increase very significantly after 1982. As discussed in Chapter 1, the LOLP would rise from 2.9 days per year in 1982 (including dependency upon interruptible loads and interconnections) to 9.0 days per year in 1983, and 13.8 days in 1985. The likelihood of blackouts and/or brownouts within the Florida Power service area thus would increase significantly. It is not possible at present to place a dollar value on the losses resulting from such power outages, but the experience of other areas in the United States suggests that these costs to power users and to society at large can be very considerable.

The overall conclusion of the cost-benefit analysis for Florida Power customers is that there is almost certain to be a positive net benefit, perhaps a very large benefit, associated with construction of the proposed power generating units.

7.2.4 EXTERNAL SOCIAL AND ECONOMIC BENEFITS

In addition to the net benefits of the proposed project to Florida Power and consumers of electricity, there will be a variety of other social and economic impacts involving local residents, businesses, and governmental units.

The government of Citrus County will receive an average of approximately $2,900,000 in annual net property taxes from Unit 4 during its first five years of operation, beginning in fiscal year 1983. Unit 5 will pay an estimated average of $2,280,000 in annual net property taxes beginning in 1985. (These are taxes based on the total value of land and improvements. Appreciation in land value will not have a major effect on tax yield prior to the completion of each facility.) The county will experience major net benefits because the proposed facilities will create relatively few demands for public services. Florida Power will pay for the construction and maintenance of any additional transportation facilities required by the new units (including water, rail, and roadway facilities) and will be self-sufficient in terms of potable water supply and sewage disposal. In addition to county taxes, Florida Power will pay approximately $40,000 in required fees to state and federal governments for permits and licensing.

The construction of the proposed power generating units will require an average of 528 workers during the 7-year construction period. The construction manpower requirement for both units combined will exceed 700 persons for more than three years and will peak at 1,275 workers in early 1982. The total payroll for the construction project will be approximately $150 million in 1978 dollars.

Based on Florida Power observations from the previous three units (without an actual survey), the construction labor force is likely to be drawn from the following areas, in terms of distance from the plant site:

25% from within a 32 kilometer (20 mile) radius
25% from within the next 32 kilometers (20 miles)
25% from within the next 32 kilometers (20 miles)
25% from within the next 32 kilometers (20 miles)

It is possible that transient labor will, in the short run, place a strain on the community. Some construction labor will utilize community facilities such as roads without paying individual property taxes. Since taxes on Units 4 and 5 will not be paid until each unit goes into operation, the community may experience a period during which the proposed project has a net negative impact on local government finance. The initial tax payments on Unit 4 should more than adequately compensate for any stresses created during this period.

Contract labor and other specialized labor services for plant maintenance are expected to cost approximately $500,000 in 1983 and $250,000 in 1984 (expressed in present dollars). With the start-up of Unit 5, the figure will total approximately $300,000 in 1985 and each year thereafter (with the exception of every fifth year throughout the lives of the plants, when the total will reach about $500,000). The higher costs every fifth year will involve activities such as warranty checks and turbine engine rebuilding. Since these costs will involve highly specialized labor, not all of the payments will contribute to the local economy. The intent is, however, to utilize the local labor market whenever possible.

It is anticipated that various construction materials, such as concrete, fill material, and lumber will be purchased from local suppliers on a competitive basis. Other local purchases could include tools, office supplies, automotive parts, hardware, first aid and safety supplies, fuels, and lubricants. When available in the area, construction equipment and vehicles will probably be rented from local sources by contractors. Purchases of consumer goods by construction workers, both resident and transient, have contributed importantly to the local economy during previous projects, and are expected to have a similar impact during the construction of Units 4 and 5.

After start-up, the operation and maintenance of Unit 4 are expected to create 112 jobs at a labor cost of approximately $3,024,000 per annum. Since a portion of Unit 4 personnel could be used for the operation of both plants, it will be necessary to hire only an additional 20 persons when Unit 5 is brought on line in 1984. This will increase the cost of labor by $420,000 to a total of $3,444,000 per year starting in 1985.

It is expected that the local labor market will be able to supply some of the skills necessary to operate the plants. Florida Power intends to utilize the local labor market to the maximum extent possible. Thus, a sizable fraction of the above mentioned payroll should go to existing Citrus County residents. In addition, most of the other workers hired will become residents of the county, and the multiplier effects of local spending by these employees will have a broad influence on the local economy.

7.3 EXTERNAL SOCIAL AND ECONOMIC COSTS

The following discussion deals with the potentially negative social and economic effects of Crystal River Units 4 and 5. Four categories of impact are considered: labor force, housing, land use, and other costs. These would be largely non-monetary costs in that dollar outlays would not be involved. The effects on labor force and housing conditions would be short-term in nature, whereas the land use and other effects would be long-term.

7.3.1 LABOR FORCE

The proposed project's positive effects on employment and payrolls in Citrus County have already been noted. The negative effects would include the possibilities of creating labor shortages during the construction project and unemployment afterward. It is worthwhile in this regard to examine the effects of the Crystal River Unit 3 construction project, although the historical data are somewhat difficult to interpret due to other trends in the county.

Labor force and employment statistics for Citrus County in the years 1970 through 1976 are presented in Table 7.3-1. Construction employment at Unit 3 reached a peak of 1,700 workers in 1973. (Construction employment appears in Table 7.3-1 as a separate category under Nonagricultural Wage and Salary Employment, and also constitutes a substantial part of the total for "All Other Nonagricultural Employment"). The power plant construction peak coincided with a high level of homebuilding and real estate activity. As a result, the number of jobs in Citrus County climbed to 9,760 in 1973, an increase of 120 percent over 1970. The number of employed Citrus County residents also more than doubled over this period, reaching 11,520 workers in 1973.

The decline in construction employment at Crystal River in 1974 was followed closely by a major slump in real estate activity. There was a loss of nearly 50 percent in construction employment and more than 60 percent in finance and real estate employment between 1973 and 1975. However, the size of the civilian labor force continued to increase. The consequence was a jump in the unemployment rate from 3.4 percent in 1973 to 13.4 percent in 1975, and 14.5 percent in 1976. The Crystal River Unit 3 project was not the only factor responsible for this gain in unemployment, and probably was not the major factor since this gain also corresponds with the general economic recession in the mid-1970's. However, some portion of the unemployed persons present in 1975 and 1976 were probably construction workers who had been attracted to the area by the Crystal River project.

Table 7.3-1. Trends in Labor Force and Employment by Major Industry in Citrus County, Florida: 1970-1976

	March 1970	March 1971	March 1972	March 1973	March 1974	March 1975	March 1976*	Change 1970-1976	
								Number	Percent
LABOR FORCE SERIES †									
Civilian Labor Force	5,620	6,580	8,280	11,920	11,900	12,400	13,200	7,580	134.9
Total Unemployment	140	200	320	400	700	1,700	1,900	1,760	1,257.1
- Unemployment Rate	2.5	3.1	4.0	3.4	5.9	13.4	14.5	---	---
Total Employment	5,480	6,380	7,960	11,520	11,200	10,700	11,300	5,820	106.2
ESTABLISHMENT SERIES**									
Nonagricultural Wage and Salary Employment	2,740	3,300	4,180	6,300	6,200	5,700	5,900	3,160	115.3
- Manufacturing	140	140	200	260	320	400	300	160	114.3
- Construction	300	420	560	1,380	840	700	600	300	100.0
- Transportation, Communications, and Utilities	180	220	260	300	360	500	500	320	177.8
- Wholesale & Retail Trade	620	720	980	1,220	1,300	1,400	1,600		
- Finance, Insurance, Real Estate	160	300	420	800	780	300	300	980	158.1
- Services and Miscellaneous	700	820	940	1,160	1,120	1,000	1,100	400	57.1
- Government	640	680	820	1,180	1,480	1,400	1,500	860	134.4
All Other Nonagricultural Employment	1,500	1,860	2,340	3,280	3,060	NA	NA	---	---
Agricultural Employment	180	180	180	180	180	200	200	20	11.1
Total Employment	4,420	5,340	6,700	9,760	9,440	---	---	---	---

NA = Not available.
† Estimates in labor force series are based on place of residence.
** Estimates in establishment series are based on place of work.
* Preliminary.

SOURCE: State of Florida Department of Commerce, Division of Employment Security, Office of Research and Statistics, Basic Labor Market Information, May 1976 and May 1977.

A second type of labor force impact would involve labor shortages and upward pressure on wages during the peak construction period. Construction projects generally pay higher wages than do other activities employing blue-collar labor, and thus can draw workers away from other sectors. In addition to causing labor shortages, this situation could possibly involve a general escalation in wage rates which would be a burden to other employers. There is little indication that these problems actually occurred during the construction of Unit 3, however. Even at the peak of construction activity, Citrus County remained a labor-exporting area, with nearly 2,000 more employed residents than jobs within the County.

The construction of Units 4 and 5 would be expected to cause substantially less disruption in the local labor market than Unit 3, for two reasons: (1) the scale of the local economy has increased substantially in the intervening years; and (2) the period of intensive construction activity will be spread out over time to a substantially greater extent for Units 4 and 5 than for Unit 3. The construction of Unit 3 at one point accounted for more than 15 percent of all jobs in Citrus County, whereas the proposed project is not likely to exceed 10 percent of the at-place employment in the county. During the declining phase of the proposed project (from early 1982 to 1984), there will be a reduction of 1,125 jobs at Crystal River, or 563 jobs per year. However, Citrus County has a long-term growth rate of 600 to 1,000 jobs per year (see Table 7.3-1). Thus, it is likely that construction workers remaining in the area after the proposed project will be able to find alternative employment. The overall conclusion is that the proposed project will not have major negative impacts on the local labor market, and certainly will have no effects sufficient to offset the positive influence of construction payrolls on the local economy.

7.3.2 HOUSING

The influx of construction workers to Citrus County could potentially create stress on the local housing market. The experience of the Unit 3 construction period suggests that an overall housing shortage is unlikely, although it is possible that a shortage was prevented in 1972 and 1973 by the ongoing boom in housing construction. The demand for dwelling units as a result of Units 4 and 5 should be less than the demand due to construction of Unit 3.

The major housing impact to be expected will be inflation in the price of rental housing. Earlier experience suggests that local landlords will respond to the strong demand for short-term housing by raising the rental rates for virtually all available units. This phenomenon may involve a temporary hardship for local residents who will be forced to pay inflated rates throughout approximately the duration of the construction project. A similar phenomenon may occur with regard to the sale prices of less expensive owner-occupied units. However, as in the case of upward pressure on wage rates, these housing impacts would represent money transfers from one group to another rather than net costs to society as a whole.

7.3.3 LAND USE

The proposed Crystal River power generating Units 4 and 5 would clearly be consistent with existing land use patterns. The site is already the location of three generating units and is bordered on all sides by undeveloped land and pine plantations. At present there are only six occupied dwelling units within 6 kilometers (4 miles) of the plant site (as measured from the proposed stack location for Units 4 and 5). Most land within 6 kilometers (4 miles) of the site, and virtually all land within 5 kilometers (3 miles), is zoned for mining and industrial use. Maps of present land use and zoning are presented elsewhere in this report (Figures 2.2-2 and 2.2-3). On the other hand, there are a number of existing dwellings and large areas of residentially-zoned land located between 6 and 8 kilometers (4 and 5 miles) from the site. The existing development is concentrated in the communities of Yankeetown and Inglis and along the south bank of the Withlacoochee River, whereas a large proportion of the vacant residentially-zoned land is found in the Crystal Manor subdivision to the east of U.S. Highway 19-98. Crystal Manor was tracted and sold in roughly 1-acre lots through interstate land sales, but presently contains only ten dwellings and no signs of additional construction activities.

The issue of land use compatibility relates primarily to future growth. Over the past decade, Citrus County has been one of the fastest-growing counties per capita in the nation. The population of the county more than doubled between 1960 and 1970, and doubled again between 1970 and 1977. The emergence of Citrus County as a retirement community was overwhelmingly responsible for these population gains. As of early 1978, it is estimated that retired persons account for over 40 percent of the Citrus County population. Rapid growth is expected to continue in the future. The Bureau of Economic and Business Research (BEBR), University of Florida, has forecasted that the Citrus County population will increase from its estimated 1977 level of 38,591 persons to a total of 82,200 inhabitants in the year 2000 (medium projection). Thus, there will be a gain of roughly 43,600 persons, or 78 persons per square mile of land area in the county.

When interpreting these trends, it should be noted that the high percentage rates of growth have been due in part to the small initial population base in Citrus County. The population increases remain fairly small-scale compared with many urban areas. For example, according to the BEBR, there will be 19 other counties in Florida for which the gains in population density between 1977 and the year 2000 will exceed the 78 persons per square mile increase predicted for Citrus County. The overall Citrus County density of 147 persons per square mile in the year 2000 will be below the present population density of the state of Florida as a whole.

It is clear that the future population growth projected for Citrus County can potentially be attained without substantial land development near the Crystal River power plant site. Recent development has been heavily concentrated in the central portion of the county and in the immediate vicinity of Crystal River 11 kilometers (7 miles) from the proposed power generating units. The population gains expected between 1977 and the year 2000 could be accommodated on only 1 to 2 percent of the land area in the county, assuming an average dwelling unit density of 3 to 5 units per acre. Thus, land shortages will not be a factor in shifting new development toward the power plant site. Some housing construction is likely to occur at Crystal Manor, however, when the remainder of the land purchasers take title for lots in that subdivision. Development at Crystal Manor and in the residentially-zoned areas along the Withlacoochee River and northwest of Crystal River would constitute a very mild land use conflict with the proposed power generating facilities given the approximately 6 to 10 kilometer (4 to 6 mile) distance of these areas from the power plant site. It is not considered appropriate to assign a negative land use impact to the proposed project on this account since the new power generating facilities are expected to be in place before the development in question occurs.

7.3.4 OTHER SOCIAL AND ECONOMIC COSTS

There are a variety of other potential impacts of the proposed project on social and economic conditions. These possible effects involve public facilities, aesthetics, recreation, cultural resources, and natural resource production. Most are expected to be minor in significance.

U.S. Highway 19-98 is the only major road leading to the project site. Recently this highway was completely four-laned north and south of the plant site; it can now accommodate up to 22,500 cars a day. Projections of highway usage developed by the Withlacoochee Regional Planning Council, which take into account the construction and operation of Units 4 and 5, show that U.S. 19-98 will reach capacity south of Crystal River in the year 1987, north of Crystal River in 2010, and in the vicinity of Red Level in 2056. Several minor roads in the area also have recently been improved. Therefore, highway conditions in the area are generally better than the conditions prevailing when the first three units were constructed at the Crystal River site.

Units 4 and 5 will place no direct burdens on public water and sewer systems, as noted earlier. Of course, the increases in population in the area caused by the construction and operation of the units will add to demands for these and other public services. It is anticipated, however, that the additional demands can be readily met by existing facilities in the county. Local schools, hospitals, and other public facilities were adequate to serve the influx of population during the construction of Unit 3. According to the Superintendent of Citrus County Schools, a new primary school is planned to open in 1979. The existing high schools and middle schools in the area have adequate capacity to absorb additional students.

Noise created by construction is not expected to cause any disturbance to the populace, due to the rural nature of the surrounding area. The negative aesthetic effects of construction will be minimal, because the proposed site is located within an existing power generation complex.

The scenic value of the site area will be altered slightly by the addition of the proposed power generating units, stacks, and cooling towers to the existing complex. The stacks will be clearly visible from the coastline north and south of the plant, and from a few points on U.S. Highway 19-98 to the east. Whether the group of four stacks will represent a significantly greater visual impact than the two existing stacks is a purely subjective matter. There will be a plume emanating from each of the new stacks which will be visible only in the immediate vicinity of the stack (due to dispersion). The effluent will be light in color but nevertheless will represent a negative visual impact. The cooling tower drift may be visible under some meteorological conditions, but should not represent a significant aesthetic impact.

As previously discussed, the land to be occupied by the proposed facilities (as distinguished from the Florida Power property as a whole) is without notable scenic, recreational, historic, cultural, or archaeological value. The lack of value for recreation is related to the absence of attractive beaches and convenient water access. Since the shallow waters off the Gulf Coast in the Crystal River vicinity impose a natural barrier, commercial fishing has never become a major industry in the area. However, shrimpers and mullet boats frequently harvest the coastal waters. Sport fishing is a popular recreational activity in this vicinity, especially near the existing discharge channel during winter months. Units 4 and 5 will have little tendency to enhance or retard these sport fishing activities. Because of the consistency of the proposed project with existing land use and zoning, the two new power generation units are expected to have little impact on nearby property values. No persons will be displaced by the project.

A small cost can be assigned to the loss of potential forest products as a result of the proposed project. The land to be occupied by the power generating units and supporting facilities has not been managed in recent years for purposes of timber production; but the loss of this use could, nevertheless, be considered an opportunity cost. The total stumpage value of timber harvested in Florida in 1974, the last year for which data are available, was $74.7 million (State of Florida, Division of Forestry, 1974). The total land area of tree farms in the state was 2.67 million hectares (6.6 million acres) (American Forest Institute, 1975). Thus, the average dollar value of stumpage was $28 per hectare per year, or roughly $35 per hectare in present dollars ($11.32 per acre and $14.14 per acre, respectively). The potential value of forest products from the 138 hectares (320 acres) involved in the proposed project would thus amount to roughly $5,000 per year. On a capitalized basis, this value stream represents a land value increment of somewhat less than $50,000.

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8.0 ALTERNATIVE ENERGY SOURCES AND SITES

8.1 MANAGEMENT ALTERNATIVES

8.1.1 CONSTRAINT IDENTIFICATION

Florida Power Corporation has forecast that the total net energy use by its customers will increase from 17,540 Gigawatt hours (Gwh) in 1977 to 26,320 Gwh in 1987, and 33,418 Gwh in 1997. These forecasts represent a compound annual percent increase of 3.26 percent over the 20-year period. Even though these forecasts indicate substantial increases in energy demands in the future, the forecasts also represent substantially lower growth rates than prevailed in the immediate past. By comparison, between 1968 and 1977, the net energy use increased at a compound annual rate of 9.69 percent. The forecasted reductions in growth rates are due primarily to the anticipated slowdown in population growth, the saturation of residential customers with appliances, and the reduction in sales to Seminole Electric Cooperative, Inc. The computer modeling studies and assumptions used to derive these forecasts are described in detail in Chapter 1.0.

Based on its demand forecasts and its present system capacity, Florida Power has determined the need for additional generating capacity to meet its forecasted demands and to maintain the reliability of its electric generation system. Generation capacity planning studies conducted by Florida Power indicate that a rapid reduction in reserve capacity would occur after 1982 without major additions to its system's generating capacity (see Chapter 1).

For capacity planning purposes, Florida Power has developed a generation expansion plan to meet its needs for additional capacity. The generation expansion plan is described in Chapter 1.0. The plan is comprised of a mixture of base load coal generation, mid-range (combined cycle) generation, simple cycle combustion turbine generation, and capacity purchases from other utilities. In developing the plan, the management alternatives open to Florida Power include the following: (1) not to generate or purchase additional power; (2) to purchase the required energy from other sources; (3) to uprate and continue operation of older units or to reactivate retired plants; (4) to enter into a joint project for providing new generating capacity; (5) to construct smaller units than the facilities proposed; and (6) to construct the proposed power generating facilities.

These management alternatives are discussed and evaluated in the following sections.

8.1.2 OMISSION OF PROPOSED PROJECT WITHOUT SUBSTITUTE ENERGY SOURCES

In order to assess the reliability of the electric generation system, computations of loss of load probability (LOLP) under various alternatives are used. The LOLP assessment uses statistical models that relate the uncertainty of load and generating capacity availability to yield a measured index of the reliability of supply. The LOLP is calculated from a forecast of weekly peak demand and variances, and the projected forced outage rates and scheduled outages for each generating unit. A LOLP value of one day in 10 years has been generally accepted throughout the electric utility industry as a reasonable design goal. For purposes of generating capacity planning, it has been determined that a criterion of 2.5 days per year dependency upon interruptible loads and interconnections is equivalent to one day in ten years LOLP for firm loads.

The projected system dependency in terms of loss of load probability is presented for the alternatives with and without the proposed units in Table 8.1-1. As shown in the upper portion of the table, the addition of 640 Mw units in 1982 and 1984, as proposed, would bring the LOLP close to the desired value of 2.5 days per year by 1983, and would lower it below this criterion in the two subsequent years. However, if the 1982 unit were omitted, the LOLP would be between 8 and 18 in the years beginning with 1983. Omission of the 1984 unit as well as the 1982 unit would create a situation of negative reserves in 1985 and 1986, with LOLP values exceeding 30. These projections of LOLP include the other planned additions to the Florida Power generating capacity as described in the generation expansion plan in Section 1.3.

Omission of the proposed power generating facilities, with no substitution of alternative power sources, would thus result in a system having greatly increased loss of load probability values. The omission would jeopardize the reliability of the electrical supply in Florida Power's service area and act as a detriment to the interconnected systems of the State of Florida. Unlike distribution-initiated service interruptions which affect only a small number of individual customers, blackouts or

Table 8.1-1. Projected Florida Power System Dependency With and Without Proposed Units

	Capacity in Mw	Winter Peak Demand, Mw*	Reserves		LOLP
			Mw	%	Days/Year
With Both Proposed Units Included					
1978†	4,554	4,150	404	9.7	12.2
1979	5,055	4,450	605	13.6	4.6
1980	5,275	4,750	525	11.1	3.1
1981	5,530	5,050	480	9.5	3.1
1982	5,985	5,360	625	11.7	2.3
1983	6,485	5,660	825	14.6	2.8
1984	6,235	5,760	475	8.2	1.7
1985	6,845	6,050	795	13.1	1.5
1986	7,441	6,140	1,301	21.2	0.7
1987	7,374	6,310	1,064	16.9	1.3
With 1982 Unit Excluded					
1982	5,985	5,360	625	11.7	2.9
1983	5,845	5,660	185	3.3	9.0
1984	5,595	5,760	-165	-2.8	5.6
1985	6,205	6,050	155	-2.5	5.3
1986	6,801	6,140	661	10.8	2.9
1987	6,734	6,310	424	6.7	4.7
With Both Proposed Units Excluded					
1984	5,595	5,760	-165	-2.9	12.2
1985	5,565	6,050	-485	-8.0	13.8
1986	6,161	6,140	21	0.3	9.1
1987	6,094	6,310	-216	-3.4	14.1

*Winter peak is assumed to occur in January of each year.
†Figures for 1978 represent actual calculations.

Source: Florida Power Corporation, 1978.

brownouts due to lack of overall system capacity impact large segments of the service area simultaneously. Such outages create situations which are not only expensive and inconvenient to customers but endanger the health and safety of the community. Therefore, in order to maintain acceptable levels of LOLP, the Florida Power system will require the additional capacity provided by the proposed project or by firm substitute energy sources of equivalent capacity.

8.1.3 PURCHASES OF REQUIRED ENERGY FROM OTHER SOURCES

Since the mid-1960's, Florida Power has maintained a policy of participating in mutually advantageous firm power exchanges with other electric utilities, such as Tampa Electric Company and Southern Company Services, Inc. These exchanges allow the selling utility to take advantage of economies of scale, while enabling the buyer to defer capital investment and obtain efficient peak generating capacity. Florida Power is currently negotiating or has firm purchase contracts with four municipal utilities--City of Tallahassee Electric Department, City of Lakeland Department of Electric and Water Utilities, Gainesville-Alachua County Regional Utilities Electric, Water, and Sewer Board, and Orlando Utilities Commission. The importance of these purchases to the Florida Power system is shown by the fact that in the winter of 1981-82 Florida Power has planned a reserve capacity of 9.8 percent which is equivalent to the capacity purchases from other utilities. However, it is very unlikely that additional purchases of the magnitude necessary to eliminate the proposed generating facilities would be feasible within the time frame required. The excess capacity in nearby utility service areas is limited, and by 1981 the reserves for the State of Florida as a whole will be approaching the 20 percent level which is commonly considered minimal for maintenance of reliable service.

8.1.4 REACTIVATION AND/OR UPRATING OF OLDER PLANTS

A program of uprating older plants or reactivating retired units would have only limited benefits, for the following reasons. Existing turbines and generators can be uprated by only modest amounts. Sufficient generation to decrease LOLP would not be possible from reactivation of Florida Power units. If the original equipment is replaced, so that essentially a new unit is constructed, the unit would be subject to recent legislation requiring offstream cooling and stack emission controls. Such steps might require more additional land for cooling facilities and solid waste storage areas than is available at the site. In addition, older equipment is relatively inefficient and unreliable, so that such facilities generally cannot be utilized for baseload generation, as opposed to peaking capacity. Therefore, uprating and reactivation of older plants is clearly not a feasible means of fulfilling a major proportion of the capacity needs demonstrated by Florida Power.

8.1.5 JOINT PROJECTS

Florida Power has engaged in joint projects on a limited basis in the past. For example, 10 percent of the recently-completed nuclear generating capacity at Crystal River is owned by four other utilities. It is unlikely under any circumstances that further joint projects could have accounted for a large proportion of the capacity increment required by 1983. However, there may have been some additional opportunities for joint projects which could have proven favorable if investigated several years ago. These might have involved any or all of the three smaller utilities which have service areas abutting the Florida Power service area and which are each proceeding with the development of new generating capacity. Florida Power will participate in these projects indirectly through power exchanges, but could not join with these companies in fulfilling capacity requirements at the present time. There is some possibility of a future joint project between Florida Power and Seminole Electric Cooperative, but such an arrangement cannot fulfill Florida Power's additional capacity needs in the 1982 to 1984 period.

8.1.6 CONSTRUCTION OF SMALLER UNITS THAN THE PROPOSED FACILITIES

The demand forecasts demonstrate that major new generating capacity is needed for the Florida Power service area by 1984. A small portion of this additional capacity will be provided by combined cycle and simple cycle combustion turbine-type generation; however, for system efficiency the majority of additional capacity should be provided by larger base-load generation units. Three potential unit sizes have been considered by Florida Power on the assumption that the most efficient means of obtaining the needed capacity would be the construction of two units. These sizes were 550 Mw, 600 Mw, and 640 Mw. The 600 Mw size was developed from a conceptual viewpoint, whereas the other two unit sizes represent standard turbines presently available to the industry. Studies by Florida Power have indicated that the incremental savings in variable costs associated with the 640 Mw size would outweigh the incremental fixed costs of the larger unit. The 640 Mw size was therefore selected as the most economical system alternative.

The possibility of siting the two 640 Mw power generating units at different locations was considered in some detail. The use of different sites would present some opportunities for minimizing transmission distances. On the other hand, a number of the facilities needed to serve the two units would have to be duplicated if the units were sited apart. These facilities would include access roads, solid waste disposal areas, coal handling systems, water treatment facilities, and power transmission corridors. In addition to the economic advantages of pooling these facilities, there would be fewer environmental impacts, all else being equal, than if two separate sites were utilized. Therefore, the site selection process has assumed (subject to later review) that the most viable option in economic and environmental terms would be to construct two 640 Mw generating units at the same location.

8.1.7 CONSTRUCTION OF THE FACILITIES AS PROPOSED

The construction of two linked 640 Mw units, to be completed respectively in late 1982 and early 1984, was judged the best feasible management alternative in terms of system reliability, capacity, and cost. The units would come on-line at the appropriate times to meet the growing demands for energy in the Florida Power service area and to provide adequate system reserves.

8.2 ALTERNATIVE ENERGY SOURCES

8.2.1 CONSTRAINT IDENTIFICATION

The possible means of power generation include nuclear, coal, oil, gas, hydroelectric, solar, and geothermal. The primary constraints which apply to Florida Power Corporation regardless of present plans and customer needs are: (1) the physiography of the siting region; (2) the current state of technology; (3) government policies regarding conservation of scarce resources; and (4) fuel availability. The topography and geology of Florida rule out the development of hydroelectric power and/or the use of pumped storage. Solar, geothermal, and other new-line power generation alternatives have not been developed to the point at which they could feasibly be utilized for large-scale power generation in Florida. The use of oil for electric power generation is being curtailed by government regulation. Finally, the availability of natural gas is doubtful. The recoverable reserves of natural gas may be much larger than is commonly believed, so that the present shortage situation might be alleviated in the future; however, this possibility cannot be counted on in planning long-term commitments. The alternative energy sources which can feasibly be considered by Florida Power are therefore limited to coal and nuclear power.

8.2.2 NUCLEAR

The lead time required for licensing, design, and construction of a nuclear power generating facility is presently close to 10 years. Based on previous analysis of the need for power in Chapter 1.0, Florida Power must have the two proposed units on-line by 1982 and 1984. In addition, there are numerous regulatory and financial uncertainties surrounding construction of nuclear units and disposition of used nuclear fuel. Florida Power has experienced some of these potential difficulties in the licensing, construction, and operation and maintenance of Crystal River Unit 3. Thus, nuclear power has not been considered a feasible alternative for the facilities under discussion.

8.2.3 COAL

Coal, the only remaining energy alternative, can be obtained for the proposed power generating units from either the eastern or western states. An economic analysis has been conducted by Florida Power to establish the relative favorability of low-sulfur versus high-sulfur coal. The computations were based upon two 640-Mw units at the Crystal River site with freshwater cooling towers. However, the cost elements considered would be common to most of the feasible cost/plant/site options. The issue addressed was the trade-off between higher fuel costs with low-sulfur coal, versus higher capital and operating costs with high-sulfur coal due to the use of scrubbers for sulfur removal. Low-sulfur coal was defined as a product which yields 0.6 pounds of sulfur or less per million Btu (MBtu) when burned. The prospective coal supplies discussed below range from 0.40 to 0.59 pounds of sulfur per MBtu. The assumptions involved in the cost analysis were the following:

1. Cost of capital equals 11.1 percent.
2. Operation and maintenance cost for low-sulfur coal units will be 1.8 mills per kilowatt-hour in 1982 and will escalate at 6 percent per year over the life of the unit, based on past industry experience with similar units.
3. Operation and maintenance cost for a high-sulfur coal unit will be twice that of a low-sulfur coal unit. The cost difference is related to the need for approximately 50 additional employees to operate and maintain flue gas desulfurization equipment, and the need for 540,000 metric tons (600,000 tons) of limestone per year. (See also the differences in heat rate and plant size noted in Item 6 below).
4. Fuel costs for the year beginning October 1, 1978, will be \$1.74 per MBtu for high-sulfur coal and \$1.94 per MBtu for low-sulfur coal.
5. Fuel prices will escalate at 10 percent per year through 1980 and 5 percent per year thereafter. The escalation over the

next two years is expected to reflect the impacts of the recent United Mine Workers of America contract settlement, the Federal Surface Mining Control and Reclamation Act of 1977, and the Black Lung Benefits Revenue Act of 1977. A leveling off in escalation rates is expected after 1980 based on the belief that the effects of recent regulations will have been largely realized and that the coal industry will have stabilized beyond its current level of activity.

6. The heat rate for a high-sulfur coal unit will be 9,800 Btu per kilowatt-hour, versus 9,400 Btu per kilowatt-hour for a low-sulfur unit. The reason is that an energy increment of between 28 and 32 Mw will be required in the high-sulfur coal unit for operation of the larger induced draft fans and the slurry pumps entailed by the desulfurization process and for reheating stack gases.
7. A high-sulfur coal unit must be 5 percent larger than a low-sulfur coal unit in order to achieve the same net output because of the internal power requirements just mentioned.
8. Plant life will be 30 years.

The computed total costs, expressed as the present worth of operations commencing in October 1982 and April 1984, are presented in Table 8.2-1. In the case of proposed Unit 4, it is found that the low-sulfur coal option would involve a present-worth saving of approximately $63 million in 1978 dollars relative to the high-sulfur coal plant. Although the absolute magnitude of the saving is dependent upon the assumed discount rate (equal to the cost of capital), the relative saving is not sensitive to this assumption since the annual cost of the high-sulfur coal option remains in roughly the same proportion to the low-sulfur coal option over all years of operation. (The former exceeds the latter by 4.5 percent to 7 percent.) In the case of Unit 5, the low-sulfur coal option is credited with a present-worth saving of $45 million in 1978 dollars.

An important issue to be considered, however, is the future availability and relative cost of low-sulfur coal. The figures in Table 8.2-1 involve an implicit assumption that the delivered price of low-sulfur coal consistently will be 11.1 percent higher per Btu than the delivered cost of high-sulfur coal. Two other independent computations have indicated that low-sulfur coal units will be economically preferable to high-sulfur coal units if:

1. The differential in delivered price between low-sulfur and high-sulfur coal does not exceed 22.6 percent at any time, or
2. The price differential does not exceed 13.75 percent in 1978 and does not escalate to more than 25.25 percent over a 20-year period.

Florida Power has identified six specific low-sulfur coal supplies, with recoverable reserves exceeding 820,000,000 metric tons (900,000,000 tons), for which the principals have agreed to discuss firm offerings of production, sale of reserves, or joint participation in mining. These supplies are located in Appalachia, Colorado, central Utah, and the Powder River basin in Wyoming. The evaluations of reserves have included detailed study of mining costs, investment costs, preparation costs, and transportation costs. Although firm price quotations have not been requested as yet, it is possible to anticipate the bid prices with considerable accuracy. The available information suggests that the delivered price of low-sulfur coal will not deviate from high-sulfur coal by more than the margins suggested above, due in part to the following considerations:

1. Transportation costs for coal delivered into Florida are a substantial portion of the delivered cost and will in some cases exceed the cost of the coal itself. Therefore, the future cost of fuel will be as dependent on rates of escalation in transportation, applicable to both high- and low-sulfur coals, as to the mined cost of the coal itself.
2. Mining and land reclamation costs will escalate at uniform rates regardless of the sulfur content of the coal produced.

Table 8.2-1. Hypothetical Cost Comparison of Power Generation Units Utilizing Low-Sulfur and High-Sulfur Coal

	Present Worth in Millions of October 1982 Dollars		Present Worth in Millions of April 1978 Dollars	
Unit 4	Low-Sulfur Coal	High-Sulfur Coal	Low-Sulfur Coal	High-Sulfur Coal
Capital	469.3	556.0	292.2	346.2
Fuel	1,124.9	1,051.6	700.5	654.8
Operation and Maintenance	88.0	176.0	54.8	109.6
Total Present Worth	1,682.2	1,783.6	1,047.5	1,110.6

	Present Worth in Millions of April 1984 Dollars		Present Worth in Millions of April 1978 Dollars	
Unit 5	Low-Sulfur Coal	High-Sulfur Coal	Low-Sulfur Coal	High-Sulfur Coal
Capital	359.3	427.9	191.1	227.5
Fuel	1,211.2	1,131.8	644.0	601.8
Operation and Maintenance	95.9	191.9	51.0	102.1
Total Present Worth	1,666.4	1,751.6	886.1	931.4

Sources: Florida Power Corporation, 1978.
Environmental Science and Engineering, Inc., 1978.

3. Although coal of less than 0.6 pounds sulfur per MBtu is presently in scarce supply relative to all other coals, it is anticipated that the 1977 Clean Air Act amendments will reduce the demand for compliance quality coals. There is now evidence that the availability of low-sulfur coals from the west is exceeding demand, a trend which should moderate future price increases.

Therefore, the choice of low-sulfur coal units by Florida Power appears to be an economically justifiable decision.

8.3 ASSESSMENT OF ALTERNATIVE SITES

8.3.1 INTRODUCTION

This section presents an evaluation of alternative sites for the two 640 Mw fossil-fueled power generating units proposed by Florida Power Corporation. In order not to preclude any possible sites in the initial selection process, the region considered for potential site locations included the entire state of Florida north of 27°00' North latitude and east of 85°30' West longitude, although the Florida Power service area constitutes only a portion of this region.

As part of their ongoing expansion planning process, Florida Power has conducted a large number of site selection studies, which have included aerial and field surveys, geologic studies, ecological investigations, water resource studies, and a detailed site analysis utilizing a computer model. The most extensive study, which concerned the siting of a major nuclear unit, initially considered 185 sites. On the basis of map analysis, the list was later reduced to 50 sites. Since nuclear and fossil-fuel plants have many of the same requirements, the list of 185 sites analyzed in the nuclear study was taken as a starting point in evaluating possible sites for the facilities discussed here. Several new sites were added, and a considerable number were deleted due to changes in land use, environmental conditions, or public policies since the time of the nuclear study. The resulting list of approximately 30 sites has been analyzed intensively with respect to the criteria described below.

Rather than reviewing the entire site selection process, only 11 potential sites are discussed here. This list has been obtained by eliminating all sites that were found in the course of the selection process to be either: (1) infeasible, or (2) clearly inferior to another site in the same geographic area. The resulting group of 11 sites include all those which can be described in retrospect as serious possibilities for the proposed power plant development. The locations of the 11 sites which were evaluated in detail are shown in Figure 8.3-1. The following section describes the criteria used in evaluating potential sites, the characteristics of the 11 sites chosen for discussion, the relative favorable characteristics of the sites in terms of cost and environmental impact, and the manner in which the preferred alternative was selected.

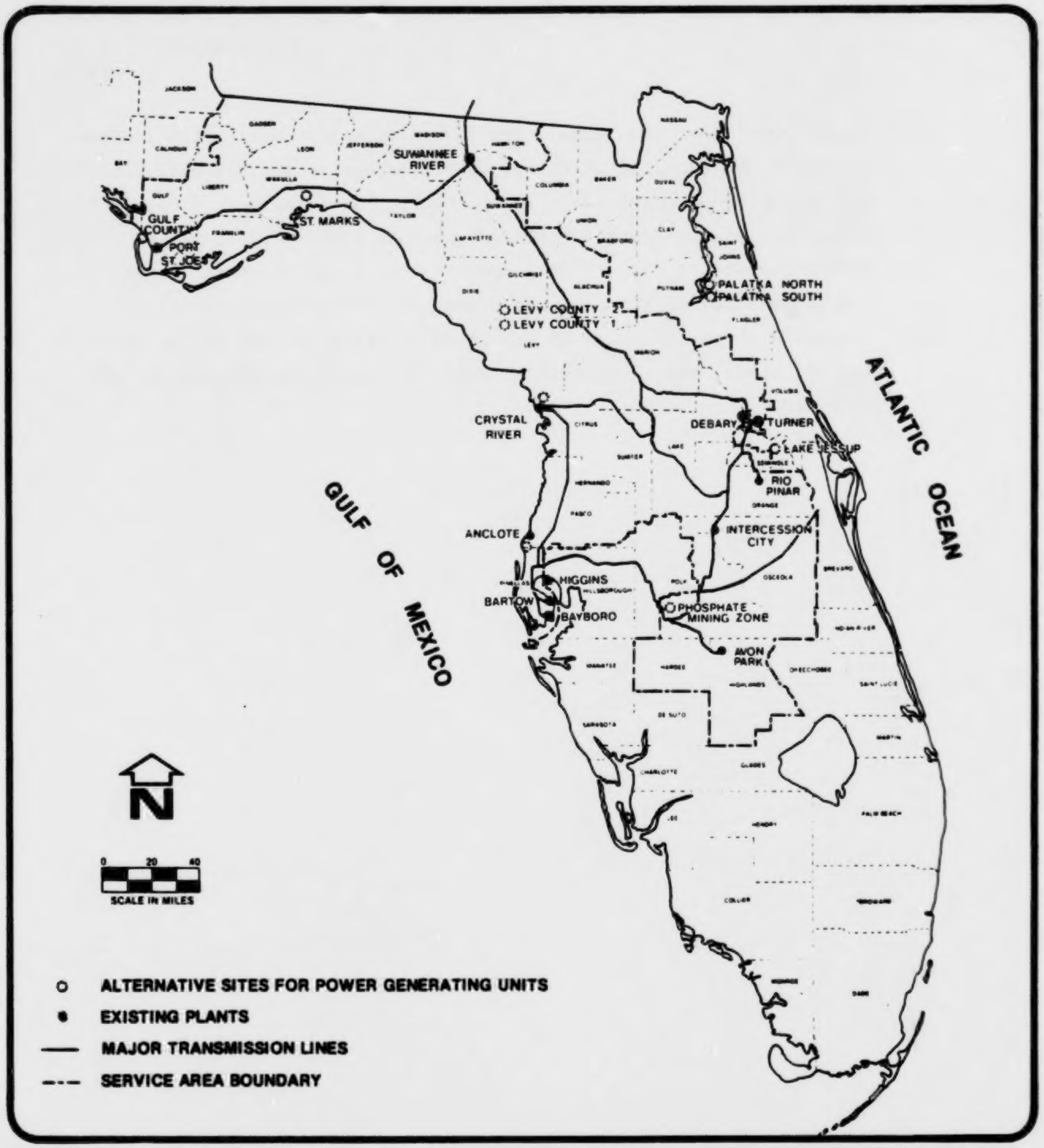

Figure 8.3-1
ALTERNATIVE SITES FOR POWER GENERATING UNITS

SOURCE: FLORIDA POWER CORPORATION, 1972
ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

8.3.2 GENERAL SITING CRITERIA

INTRODUCTION

In the initial screening process, relatively few factors were considered as absolute constraints upon the inclusion of candidate sites. A site was required to contain an adequate acreage of dry land for placement of the proposed facilities and could not involve gross conflicts with existing land use or social/cultural values. The site had to be potentially accessible by rail and highway, and preferably also by barge. The other initial evaluation criterion was that potential sources of cooling system makeup water and service water had to be available at or near the site.

Since many land parcels within the siting region possess these basic qualifications, the studies conducted by Florida Power have considered nearly 200 individual sites. However, as the description of alternatives will indicate, there are few highly favorable sites for power generation in Florida, due to environmental constraints which include air quality, water supply, aquatic ecology, wildlife habitat, and existing patterns of land and water use considerations.

The specific criteria used to evaluate candidate sites are grouped here for purposes of discussion into three categories: general siting criteria, engineering criteria, and environmental criteria. The first category generally refers to land suitability and access to transportation and transmission facilities.

LAND ACREAGE AND OWNERSHIP

The area of land required for the proposed power generating units is calculated as follows:

	Hectares	Acres
Generating plant	12	30
Access, parking, and construction laydown	53	130
Coal storage and handling	40	100
Cooling towers	5	12
Cooling ponds, up to	607	1,500
Fly and bottom ash storage	101	250
Total, with cooling towers	211	522
Total, with cooling ponds	818	2,022

These computations indicate that about 200 hectares (500 acres) are needed if the proposed facilities utilize cooling towers, whereas the power generating units with cooling ponds would require approximately 800 hectares (2,000 acres). Even if cooling towers are assumed, the land requirements are somewhat indefinite because of possible variations in ash-sludge storage. More than 100 hectares (250 acres) could be required if no user is found for residual ash.

Land acquisition costs have been considered as a criterion but are generally not a major source of cost differentials among alternative sites. More important is the possibility of land acquisition problems due to multiple ownership of the site area and/or existing residents at the site. The most-preferred situation is one in which the site consists of few individual parcels; the least-preferred situation would be one in which land condemnation proceedings are necessary.

TOPOGRAPHY AND GEOLOGY

Topography presents few obstacles to power plant development in Florida due to the generally level terrain. However, wet areas should be avoided for engineering as well as environmental reasons. Areas which are subject to flooding by storm runoff or ocean surges are obviously unfavorable. Avoidance of areas with known seismic activity is not a highly relevant criterion in Florida.

Geologic criteria relate to the ability of soils to support power plant structures, and the suitability of the site for construction of ponds and material storage areas. The critical variables in the former case are the depth to competent bedrock and the existence of solution activity, which is widespread throughout Florida. With regard to ponds and storage areas, there should preferably be impervious soils available for use as linings. The site should permit construction of ponds and storage areas in such a fashion that there will be no threats to public safety, surface water quality, or ground water quality.

TRANSPORTATION AND POWER TRANSMISSION FACILITIES

Highway access to a site is required for transportation of materials and personnel. The proximity of a site to supplies of construction labor is also potentially important. Rail access, preferably involving direct linkage to a major carrier, is required for purposes of fuel delivery. Water access has not been considered an absolute necessity for potential sites. The possibility of obtaining fuel by barge has been treated as an important positive factor in site comparisons, although it was not possible to express this factor in monetary terms.

A lack of adequate highway or rail access to a potential site was considered negative in terms of both project cost and environmental impact. The possibility of environmental impact would relate to the ecosystem disruption required for the creation of new transportation corridors. Perhaps the most important cost consideration, in general, is the influence of transportation facilities and site location on delivered fuel. Given the projected coal consumption of the proposed facilities, a $1 per ton difference in the delivered cost of coal would amount to a differential of $4,000,000 or more in annual operating costs.

The candidate sites included in the selection process were not limited to locations near the Florida Power's existing transmission lines.

However, any new transmission corridors required as part of site alternatives have been treated as elements of project cost and environmental impact in the same fashion as transportation corridors. At least two 230 kv lines, or one 500 kv line, would be required for the proposed facilities. Possible problems of right-of-way acquisition have also been considered. The line transmission losses which would be involved in serving the Florida Power's customers from the various sites were an important source of cost differentials. For the more remote sites considered, the losses would amount to significant percentages of total generating capacity.

8.3.3 ENGINEERING SITING CRITERIA

The two 640 Mw power generating units are proposed to be on-line in October 1982 and April 1984. The following basic engineering design criteria would apply at any of the alternative sites:

1. Unit life: 30 years;
2. Average annual load factor: 66 percent;
3. Net unit heat rate: 9,400 Btu/kwh (assuming low-sulfur coal);
4. Fuel consumption: roughly 3,600,000 metric tons (4,000,000 tons) per year of low-sulfur coal;
5. Cooling system: fresh-water cooling towers (cooling ponds and once-through cooling with salt water were considered as options in some cases).

Each 640-Mw unit would produce about 5.2 billion Btu per hour, of which a large proportion would be waste heat that must be dissipated by the cooling system. If cooling towers were utilized, heat dissipation for both 640-Mw units would require evaporation of 41,640 lpm (11,000 gpm) when the units were operating near capacity with a small additional amount lost in drift. The amount of cooling system makeup water required under these conditions would depend upon the water quality of the source utilized (which would determine the allowable cycles of concentration). The prevailing relationship is diagrammed in Figure 8.3-2. Under the conservative assumption that somewhat less than five cycles of concentration could be maintained, the cooling tower makeup requirement would equal 53,700 lpm (14,200 gpm), or about 76 million liters (20 million gallons) per day.

In addition to cooling system makeup water, service water would be required for drinking, cooling of bearings, and other uses. Cycle makeup water would be required for conversion to steam. Withdrawals for these uses would average about 3 mld (0.8 mgd) and would reach a maximum of approximately 5.7 mld (1.5 mgd). In addition, if scrubber systems were used to control stack emissions, an additional 5.7 mld (1.5 mgd)

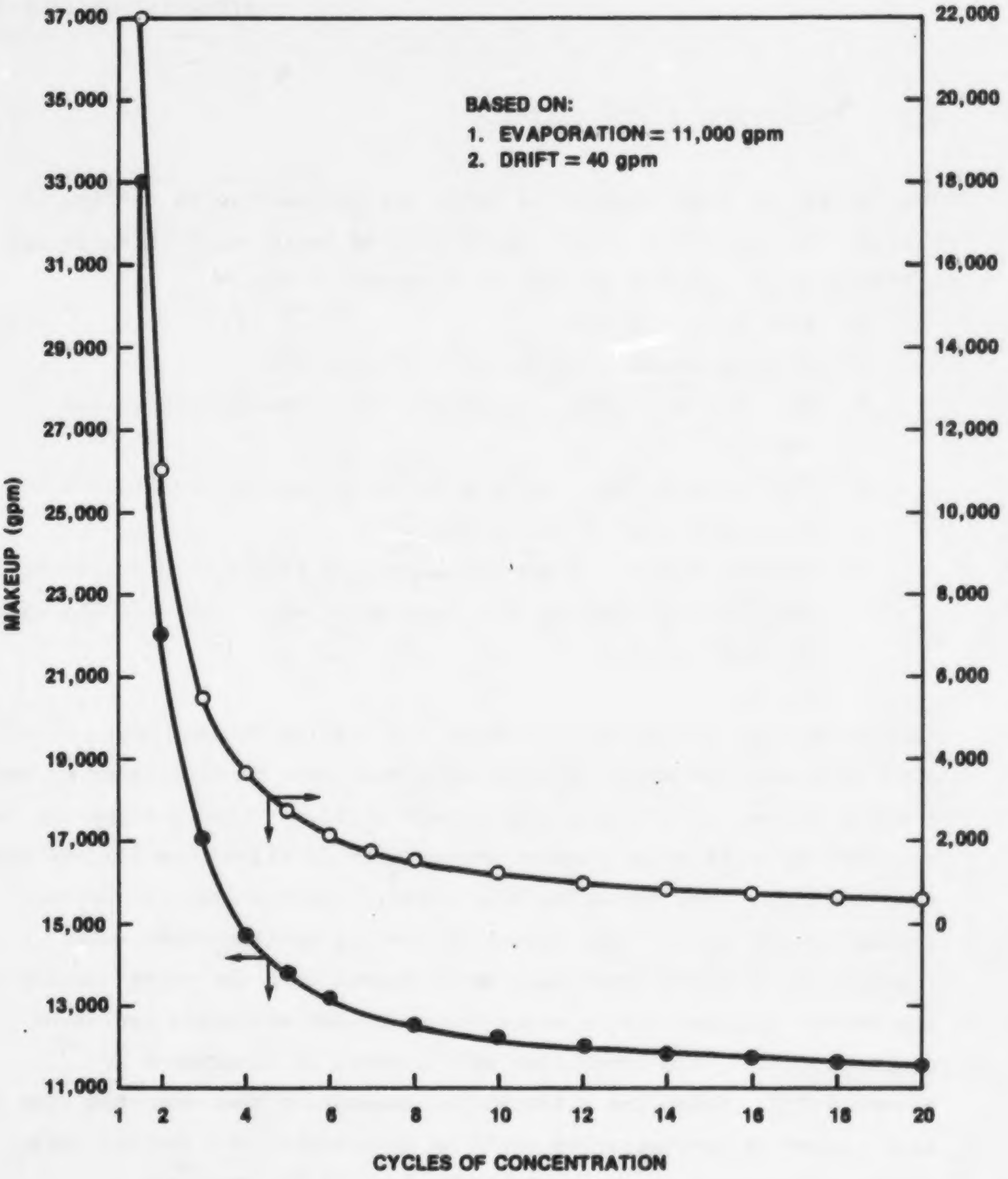

Figure 8.3-2
MAXIMUM MAKEUP AND BLOWDOWN VS. CYCLES OF CONCENTRATION IN CIRCULATING WATER FOR PROPOSED POWER GENERATING UNITS

SOURCE: FLORIDA POWER CORPORATION, 1978

FLORIDA POWER CORPORATION

PROPOSED
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CITRUS COUNTY, FLORIDA

would be needed. All of these water uses would require various levels of treatment.

A maximum freshwater withdrawal rate of 87 mld (23 mgd), obtained by summing the figures just cited, has been utilized in the site evaluation process (cooling ponds could involve somewhat smaller withdrawals if losses due to percolation are low). The impacts most commonly associated with withdrawals of this magnitude from surface waters are alterations of hydroperiod (with possible salinity effects) and entrainment of aquatic organisms. A guideline utilized in Florida is that maximum withdrawal rates from surface water bodies should not exceed 5 percent of the minimum observed 30-day flow, or the estimated 100-year minimum monthly flow. On the other hand, reliance upon groundwater supplies could affect adversely the yields of nearby wells, and could possibly risk saltwater intrusion in coastal areas. The quantity and quality of available water supplies have thus been highly important in site selection.

The wastewaters yielded by power generation include cooling system blowdown water, boiler wash, backwash, plant runoff, and runoff from storage and waste disposal areas. These wastewaters must be disposed without damage to aquatic ecosystems or surface and groundwater resources. The design of wastewater disposal systems would be expected to vary considerably among site alternatives. Such systems could include deep-well injection, percolation/evaporation, or surface water discharge, with varying levels of treatment. The evaluation of site alternatives with regard to wastewater has focused upon the feasibility and expense of disposing residuals in such a manner as to comply with all applicable water quality standards. The water quality characteristics of primary concern for discharges from steam electric generating plants are dissolved solids concentrations and temperature, although other constituents such as biocides and corrosion inhibitors can be important.

8.3.4 ENVIRONMENTAL SITING CRITERIA

The environmental criteria employed in the site selection process included air quality, water resources, aquatic and terrestrial ecology, population and land use, historical and archaeological sites, recreational resources, other socioeconomic considerations, and public safety. The most detailed criteria were those pertaining to air and water resources, since these involved specific quantitative standards established by federal and state agencies.

AIR QUALITY AND EMISSIONS

Both the federal and state governments have promulgated regulations relating to the quality of ambient air. These regulations are a major factor in obtaining approval of a site for a fossil-fueled power plant. The federal and state air quality criteria which were considered in the evaluation of alternatives are presented in the following discussion.

Federal air quality limitations which can significantly affect power plant siting are the National Ambient Air Quality Standards (NAAQS) and the Prevention of Significant Deterioration (PSD) regulations. The NAAQS were promulgated by the U.S. Environmental Protection Agency (EPA) on April 30, 1971 (40 CFR Part 50). Prevention of Significant Deterioration regulations were also promulgated by the EPA (40 CFR Part 52). More recently, however, the Congress of the United States has passed amendments to the Clean Air Act which include new provisions for PSD. The President signed into law the Clean Air Act Amendments (PL 95-95) on August 7, 1977.

The NAAQS were established to protect the health and welfare of the citizens of the United States. A distinction was established between protection of public health only, and protection of public health and welfare. The former objective would be addressed by "primary" standards, whereas the latter would be addressed by "secondary" standards. Thus, secondary NAAQS have been designed to prevent occurrences such as impairment of visibility, corrosion and damage to plants as well as public health impacts. Table 8.3-1 presents the NAAQS for total suspended particulate matter, sulfur dioxide, and nitrogen dioxide. These are the major air pollutants emitted from a fossil fuel steam electric power plant.

A new fossil-fueled power plant (exceeding 250 mm Btu/hr) must meet the emission limitation standards known as New Source Performance Standards (promulgated by the U.S. EPA in 40 CFR Part 60). Meeting these standards does not guarantee that NAAQS will not be violated, although the New Source Performance Standards make it highly unlikely that a new fossil- fueled power plant will violate NAAQS due entirely to its own emissions. NAAQS violations could occur primarily through source interaction and contribution to an existing air quality problem. Since a new source cannot cause or contribute to a violation of the NAAQS (except under provisions allowed in nonattainment areas, PL 95-95, Section 129), compliance with NAAQS must be evaluated in the site selection process.

The 1977 amendments to the Clean Air Act have significantly modified PSD requirements previously established by the EPA. The major air quality limiting features of Section 127 are the maximum allowable increases in concentrations of TSP and sulfur dioxide. A new fossil fuel power plant cannot result in any increases relative to baseline conditions which exceed the allowable increments for that area (or for a nearby area, in the case of Class I). All areas of the country are classified as either Class I, II, or III with the exception of national parks (exceeding 2,430 hectares or 6,000 acres), national wilderness areas (exceeding 4,050 hectares or 10,000 acres), and other federally designated lands (discussed in Sections 162 and 164, PL 95-95). Initially, for Florida, all areas of the state have been designated as Class II with the exception of the St. Marks, Bradwell Bay, Okefenokee, Cedar Keys, and Chassahowitza National Wilderness Areas and the Everglades National Park, which have been designated Class I. Table 8.3-2 presents the allowable air quality increments for Class I and II areas.

Table 8.3-1. National and State of Florida Ambient Air Quality Standards (ug/m^3)

Air Pollutant	Standard	Averaging Time Annual Average	 24-Hour*	 3-Hour*
Total Suspended Particulate Matter (TSP)	National Primary	75†	260	---
	National Secondary	60†	150	---
	State of Florida	60†	150	---
Sulfur Dioxide (SO_2)	National Primary	80	365	---
	National Secondary	---	---	1,300
	State of Florida	60	260	1,300
Nitrogen Dioxide (NO_2)	National Primary	100	---	---
	National Secondary	100	---	---
	State of Florida	100	---	---

* Not to be exceeded more than once per year.
† Annual geometric mean.

Source: Florida Administrative Code, 1977.

Table 8.3-2. Prevention of Significant Deterioration Increments (PL 95-95 Section 127)

Classification	Air Pollutant	Maximum Allowable Increases Over Baseline* (ug/m^3) Averaging Time: Annual Average	24-Hour†	3-Hour†
Class I	TSP	5**	10	---
	SO_2	2	5	25
Class II	TSP	19**	37	---
	SO_2	20	91	512

*Baseline refers to concentrations existing at time of first application, and sources which have commenced construction prior to January 6, 1975.

†Not to be exceeded more than once per year.

**Annual geometric mean.

Source: Public Law 95-95, 95th Congress, 1977.

Similar to the federal requirements, the State of Florida (Department of Environmental Regulation) has promulgated ambient air quality standards (AAQS) and a limitation on significant degradation. The AAQS established by the state are numerically equal to the federal secondary NAAQS (except for the annual and 24-hour sulfur dioxide standard). Since these standards are slightly more restrictive than the federal NAAQS, the state standards take precedence in evaluating compliance.

The DER recently promulgated a PSD regulation similar to the federal PSD regulation. The allowable increments in the state regulation are identical to those promulgated by PL 95-95. Therefore, no additional analysis beyond the federal level is required in evaluating sites. In order to evaluate alternative power plant sites with respect to these regulations, existing emission sources and air quality data were considered. Since Florida has generally favorable atmospheric dispersion conditions, existing air quality and sources will be the major determinants of compliance with air quality regulations. Consequently, alternative sites were evaluated primarily on these two factors.

The selection study also considered the potential effects of cooling tower fogging and drift on agriculture, local terrestrial habitats, and transportation. While there are no quantitative limiting standards for such effects, they must be evaluated on a case-by-case basis. Drift is ordinarily not a significant problem if proper safeguards are taken.

AQUATIC ECOLOGY

Impacts of power-generating facilities on water resources can also involve effects on aquatic organisms. Entrapment of organisms by intake structures is a potential impact. Certain types of water resource effects, such as thermal discharges, can possibly be beneficial to some aquatic communities; but there is usually at least an initial presumption that changes relative to baseline conditions will be negative.

Quantitative criteria generally do not exist for evaluating the impacts of alternative power plant sites on aquatic ecosystems. The procedure utilized in the selection studies, where possible, has been to review available baseline information, assess the probable magnitude of effects, and evaluate the overall importance of these impacts. The major factors considered in establishing importance are the existence of rare, endangered, or diminishing aquatic species, and the relationship of aquatic ecology to water uses, especially recreation and commercial fisheries.

TERRESTRIAL ECOLOGY

Terrestrial habitats, altered by the construction of power plant facilities, are often subject to further impact by aspects of permanent operations such as noise, air quality degradation, and cooling tower drift. Destruction of habitats is frequently the most significant environmental impact produced by construction of transmission and transportation corridors. The key factors that are considered when evaluating alternative power plant sites are: (1) the sensitivity of habitats to impact (e.g., the need to maintain a minimum habitat size); (2) the existence of species which are endangered or otherwise given protected status; and (3) the relative uniqueness of the habitats in question. The preferred site would be one in which the existing terrestrial ecosystems are not notably diverse, interesting, or valued for hunting, and are widely represented in the surrounding area.

POPULATION AND LAND USE

Fossil-fueled power plants should be sited, if possible, in areas of low population density in their immediate adjacent areas, to minimize nuisances to the public involving noise, air quality impact, transportation system usage, and other factors. Sites should not be located near sensitive areas that are incompatible with power plant construction and operation, such as parks, wilderness areas, wildlife refuges, national parks, wild and scenic rivers, and locations that may be candidates for future recognition as scenic or recreation areas. Preferably, power plant developments should avoid areas of high natural productivity (i.e., marshes and coastal zones), and should not occupy prime agricultural land. Consistency with existing zoning and land use plans is an important criterion in areas where such expressions of public preference exist.

HISTORICAL AND ARCHAEOLOGICAL SITES

The existence of significant historical or archaeological resources at a site would not necessarily disqualify the site as a power plant location but would constitute a negative factor. At the least, monetary costs and delays could result from the need for site exploration and excavation.

RECREATION

Protection of scarce recreational resources is a high priority objective in power plant siting and in environmental impact assessment. To a considerable extent, impacts on recreation are covered by the previously mentioned criteria for air quality, water quality, and ecology. The explicit recognition of recreational value primarily involves placing an especially heavy emphasis upon protection of land areas and water bodies used for this purpose. Under no circumstances should a power-generating facility displace an appreciable share of the recreational resources in an area.

OTHER SOCIOECONOMIC IMPACTS

Some of the social and economic factors which are potentially important for power plant siting are the following: (1) employment and income created by facility construction and operation; (2) social impacts of imported construction labor; (3) increase in local tax revenues due to the power generating facility, versus the impact of the facility on the total cost of providing public services; (4) effects of the power plant construction project upon local labor force conditions and wage rates; and (5) desirable and undesirable influences of the project upon regional growth and land use. No absolute criteria exist for evaluating power plant sites in terms of these factors, but they can support or detract from a specific site to a considerable extent.

WATER RESOURCES CRITERIA

The State of Florida has initiated a Comprehensive Planning Process to guide and implement orderly, long-range, economic, social and physical development (Chapter 23, Florida Statutes). The Water Element of the Comprehensive Plan proposes goals, objectives, and policies designed for optimal management of water resources in Florida (Executive Order 76-29).

The criteria set forth in the Water Element of the proposed Comprehensive Plan were used to evaluate alternative sites for Florida Power Corporation's new generating facilities. These general policy criteria are designed to:

1. Encourage all reasonable beneficial uses of water;
2. Protect water quality;
3. Protect floodplains and other wetlands;
4. Protect soil fertility and prevent erosion;
5. Maximize the production of agricultural and natural plant communities;
6. Maintain the natural hydroperiod as much as practical;
7. Prevent flood damages;
8. Prevent saltwater intrusion;
9. Provide for growth and development in areas inherently suited for such activities; and
10. Protect the functional integrity of coastal ecosystems.

The federal government and the State of Florida have promulgated extensive rules and regulations relating to the management of water resources in Florida. These regulations provide a means of enforcing the general policy criteria set forth in the proposed Water Element of the Comprehensive Plan. The major legislation which relates to these rules and regulations is presented in the following list:

Federal Legislation

PL 89-90, Water Resources Planning Act

PL 92-500, Federal Water Pollution Control Act Amendments of 1972

PL 85-624, Fish and Wildlife Coordination Act

PL 92-583, Coastal Zone Management Act of 1972

PL 89-298, Title II--Flood Control Section

PL 90-542, Wild and Scenic Rivers Act

PL 90-454, Estuarine Areas Protection and Restoration Act

PL 90-448, Housing and Urban Development Act of 1968, Title XIII--National Flood Insurance Act of 1968

PL 93-523, Safe Drinking Water Act

PL 93-234, Flood Disaster Protection Act of 1973

PL 85-500, Title III--Water Supply Act of 1958

PL 91-190, National Environmental Policy Act of 1969

State Legislation

Chapter 373, Florida Statutes (Water Managment Policy)

Chapter 403, Florida Statutes, Florida Air and Water Pollution Control Act

Section 252.44, Florida Statutes (Disaster Preparedness)

Chapter 298, Florida Statutes (Policy for Water Management Districts)

Section 298.74, Florida Statutes (Drainage of Lakes)

Chapter 380, Florida Statutes, the Florida Environmental Land and Water Management Act of 1972

Chapter 160, Florida Statutes (Advisory Role of Regional Planning Councils)

Chapter 370, Florida Statutes (Coordinating Role of Department of Natural Resources, Division of Resource Management)

Chapter 582, Florida Statutes (Policies for Prevention of Soil Erosion, Floodwater, and Sediment Damages)

Section 258.36, *Florida Statutes*, the Land Conservation Act of 1972

Chapter 23, *Florida Statutes* (Development of a State Comprehensive Plan)

Executive Order 76-29 (Inclusion of a Water Resources Element Within the State Comprehensive Plan)

Chapter 163, *Florida Statutes*, Local Government Comprehensive Planning Act

The water quality criteria established by the State of Florida (F.A.C. Chapter 17-3) and the federal government (P.L. 92-500, Section 304) are described in Table 8.3-3. Thermal criteria established by F.A.C. Chapter 17-3.05 are listed as follows (where T refers to ambient water temperature):

Zone	Streams	Lakes	Coastal		Open
			Summer	Winter	
North	90° F Max	90° F Max	92° F Max	90° F Max	97° F Max
	T + 5° F	T + 3° F	T + 2° F	T + 4° F	T + 17° F
Peninsula	92° F Max	92° F Max	92° F Max	90° F Max	97° F Max
	T + 5° F	T + 3° F	T + 2° F	T + 4° F	T + 17° F

In evaluating alternative sites for Florida Power's proposed units, the doctrine of "reasonable beneficial use" as established in Chapter 373, *Florida Statutes* was used to provide general criteria for consumptive use of waters at alternative sites. Withdrawals from surface waters were tested against a guideline of 5 percent of minimum observed 30 day flow. Proposed groundwater withdrawals were evaluated on the basis of whether or not significant effects on the potentiometric surface would occur.

Table 8.3-3. Numerical Water Quality Criteria

Parameter	Fresh Water	Saline Water
Dissolved Oxygen		
minimum	4 mg/l	4 mg/l
24-hour mean	5 mg/l	5 mg/l
Ammonia Nitrogen	0.02 mg/l*	0.4 mg/l*
Total Kjeldahl Nitrogen	0.90 mg/l †	
Nitrate Nitrogen	0.30 mg/l †	0.30 mg/l**
Nitrite Nitrogen	0.20 mg/l †	0.20 mg/l**
Phosphorus	0.06 mg/l †	0.06 mg/l**
Suspended Sediment	25 mg/l*	25 mg/l*
Pesticides/Herbicides	†	†
pH	6-8.5	6-8.5
Arsenic	50 ug/l	50 ug/l
Cadmium	0.4-3 ug/l*	5 ug/l*
Chromium	300 ug/l*	300 ug/l*
Copper	500 ug/l	500 ug/l
Iron	300 ug/l	300 ug/l
Lead	50 ug/l	50 ug/l
Manganese		100 ug/l
Mercury	0.05 ug/l*	0.1 ug/l*
Nickel	100 ug/l*	100 ug/l*
Zinc	1 mg/l	1 mg/l
Silver	†	†
Chlorine	10 ug/l*	10 ug/l*
Cyanide	None detectable	None detectable
Polychlorinated Biphenyls	0.001 ug/l*	0.00 ug/l*
Phthalate Esters	3 ug/l*	
Hydrogen Sulfide	2 ug/l*	2 ug/l*
Selenium	†	†
Total Dissolved Solids		
monthly average	500 mg/l	
maximum	1000 mg/l	
Alkalinity	20 mg/l*	20 mg/l*
Aluminum,		1.5 mg/l*
Detergents	0.5 mg/l	0.5 mg/l
Fluoride	10 mg/l	10 mg/l
Oil and Grease	15 mg/l	15 mg/l
Phenol	1 ug/l	1 ug/l
Gross Beta	1000 pCi/l	1000 pCi/l
Specific conductivity	500 umhs/cm	
Turbidity	50 JTU	50 JTU
Chloride	250 mg/l	

Table 8.3-3. Numerical Water Quality Criteria (Continued, Page 2 of 2)

Parameter	Fresh Water	Saline Water
Fecal Coliforms		
monthly geometric mean	200/100 ml	200/100 ml
10% of samples	400/100 ml	400/100 ml
any one day	800/100 ml	800/100 ml
Total Coliforms		
monthly geometric mean	1000/100 ml	1000/100 ml
20% of samples	1000/100 ml	1000/100 ml
any one day	2400/100 ml	2400/100 ml

* EPA recommended criteria (1975).

† EPA recommended criteria (1975) defined in terms of LC_{50}.

** DER--Planning Appendix to the Water Quality Management Plans.

Source: Florida Department of Environmental Regulation, 1978.

8.3.5 EVALUATION OF CANDIDATE SITES

DESCRIPTION OF CANDIDATE SITES

The general locations of the following candidate sites are shown in Figure 8.3-1.

Gulf County Site

Several sites near Port St. Joe, Gulf County (in the Florida panhandle), have received consideration in site selection studies by Florida Power. The locations have included sites along the coast at Palm Point, between Port St. Joe and Beacon Hill, and 1.6 kilometers (1 mile) northwest of Mexico Beach. The most favorable potential site, and the one considered here, is on the south side of the Gulf County Canal near its confluence with the Intracoastal Waterway.

A once-through cooling system, drawing water from the Intracoastal Waterway and discharging into the Gulf County Canal, has been proposed for the Gulf County site. Off-stream cooling could utilize the same water source. Another possibility would be fresh water from wells. The ground water is the softest and least mineralized in the state, and a high rainfall and an aquifer of unconsolidated quartz sand and gravel make a good supply of ground water probable.

Road access to the site is favorable, as Routes 71 and 382 run near the eastern boundary. Dredging of a short access canal and turning basin would allow coal barges to reach the site via the Gulf County Canal. The geographic location of the site is favorable for receiving coal barged down the Mississippi River. There is rail access at Port St. Joe, which might possibly be extended to the site by a 4-kilometer (2.5-mile) spur at little or no cost to Florida Power. As discussed later, the existing railroad service and freight cost structure in Florida for coal delivery cause this site to be considerably more expensive to serve by rail than any of the other sites considered.

A 230-kv power line extending east from Port St. Joe is presently under construction. Location of the proposed power generating units at the Gulf County site would require extensive additional improvements to the transmission system. Due to the great distance of this site from the load centers served by Florida Power, the line transmission losses would amount to a significant proportion of the total power generated.

The site seems to offer no major difficulties of topography or geology. Surficial quarternary rock is underlain by blue-grey clay, then shoal river formation, and, at about 120 meters (400 feet), chipola limestone. No earthquakes have been reported along the west coast of Florida. The area is subject to relatively frequent storms, which bring both high winds and flooding of low-lying areas. On the average, tropical storms (winds exceeding 34 knots) occur every 1.4 years, and hurricanes occur every 3.8 years.

The Intracoastal Waterway is considerably altered from natural conditions, and the Gulf County Canal is completely artificial. No data which describe the water quality and flow regime of these waterways have been located. The effects of withdrawals from the Intracoastal Waterway on currents and aquatic systems cannot be accurately predicted at present. However, a power plant at the site under discussion could clearly have adverse impacts upon St. Joseph Bay, which receives flow from the Gulf County Canal. The bay is about 24 kilometers (15 miles) long and 8 kilometers (5 miles) wide, with a surface area of 17,732 hectares (43,782 acres). The single opening to the Gulf of Mexico is about 3.2 kilometers (2 miles) wide, and tidal range averages about 0.5 meters (1.4 feet). Most of the bay has been classified by the State of Florida Department of Environmental Regulation as suitable for shellfish propagation and harvesting. Some sludge deposits and oxygen depression presently occur within a 1.6- to 2.4-kilometer (1- to 1.5-mile) radius of the canal outlet because of paper mill waste discharges. Heated water discharged into the canal would flow 8 kilometers (5 miles) and would cool considerably before entering St. Joseph Bay. However, supersaline water would not be diluted. The effects of thermal and saline additions to the bay could be serious, since there is considerable doubt whether the flushing rates for the bay would be adequate to dissipate these effluents.

The site is wholly owned by the St. Joe Paper Company. It is about two-thirds covered by planted pine, with the remainder consisting of fresh-water marsh. Both these habitats are widely represented in the area. Population density in the region is low, and there are no buildings on the site, which is presently used for tree farming. The nearest population center is Port St. Joe (population 4,246 in 1977), located 3.2 kilometers (2 miles) to the southwest. There is some industrial development on the Gulf County Canal to the north of Port St. Joe. The only known place of historic or archaeological interest in the area is the town of Port St. Joe, which was the site of the first State Constitutional Convention in 1878. The Pig Island Wildlife Reserve and the T.H. Stone State Park are located in the general vicinity of the site.

With regard to air quality, there are presently major sources of particulates (TSP) near the proposed Gulf County site, the most significant being the St. Joe Paper Company pulp mill in Port St. Joe. A new steam electric power plant could comply readily with NAAQS and PSD requirements pertaining to sulfur dioxide concentrations; but the concentrations of particulates would have to be investigated closely. In addition, this site has lower dispersion potential than sites further east and south in Florida.

St. Marks

The St. Marks site is located in Wakulla County about 1.2 kilometers (0.7 miles) southeast of Newport, 0.8 kilometers (0.5 mile) east of St. Marks River, and 3.2 kilometers (2 miles) northeast of St. Marks. The site lies in the river floodplain at an average elevation of about 5.2 meters (17 feet) which is an undesirable feature for a power plant site. The only sources of water are wells and the St. Marks River. The quality of ground and surface waters is not known, but ground water apparently contains sulfur. The average flow of the St. Marks River (1956-1973) 18,860 lps (666 cfs) at a point about 10 kilometers (6 miles) upstream from the site and the minimum of record is 8,778 lps (310 cfs). The proposed power generating facilities would require about one-tenth of the minimum flow for cooling water make-up, so that alteration of hydroperiod could be a major problem. Other uses of this water are not known.

Road access is good; State Road 59 runs along the eastern boundary of the site. The Seaboard Coastline Railroad serves St. Marks, and access could be provided to the site by constructing about 4 kilometers (2.5 miles) of new track. Barge access to the site would require extensive dredging. There is an existing 230 kw transmission line nearby, but the site is quite distant from the major areas of power need, so that transmission losses (i.e., voltage drops) would be considerable.

The geologic foundation at the site is sandy, chalky limestone. Although the cooling requirements of the proposed facilties would amount to 5 percent of the average flow of the St. Marks River, the effects on the estuary to the south would be moderated by the fact that the St. Marks joins with the larger Wakulla River about 6 kilometers (4 miles) downstream from the site. The estuary and a great deal of the neighboring coast is within St. Marks National Wildlife Refuge. Although the plant would not necessarily have major negative impacts on the estuary, the sensitivity of the area would mandate a careful demonstration of no-effect.

County maps show no buildings on the site. Marsh hammocks and saw palmetto-pine cover the site. Both habitats are extensive in the area. The site, which is located within the Aucilla Wildlife Management Area, is 0.8 kilometers (0.5 miles) from the border of the St. Marks National Wildlife Refuge. Population density in the region is generally low, but the site is only 0.8 kilometers (0.5 miles) from the community of Newport, and only 3.2 kilometers (2 miles) from St. Marks (population

293 in 1977). The archaeological and historical resources of the site are unknown.

Air quality in the vicinity of the St. Marks site is affected by some sources of TSP and sulfur dioxide, which include the 151 Mw oil-fired power plant operated by the City of Tallahassee just south of the proposed site. More important, the nearby St. Marks Wilderness Area has been designated a Class I air management area by virtue of the recent Clean Air Act Amendments. This fact could severely constrain future power plant development.

Levy County (2 Sites)

The southern Levy County site lies on the east bank of the Suwannee River, about 13 kilometers (8 miles) west of Chiefland (population 2,036 in 1977), and 2.4 kilometers (1.5 miles) south of Manatee State Park. Road access is provided by paved County Road 347 along the eastern boundary. Barges could reach the site via the Suwannee River; but the increase in river traffic caused by barging coal to the site might constitute a significant impact. Rail service by the Seaboard Coastline Railroad through Chiefland would require at least 32 kilometers (20 miles) of new track.

A second potential site in this area is located about 10 kilometers (6 miles) to the north. This site also occupies the east bank of the Suwannee River and lies between the town of Suwannee River (population 225 in 1977) and Manatee Springs State Park. Road and rail access would be from the U.S. 19 corridor about 4 kilometers (2.5 miles) away.

The nearest 230 kw transmission line is located in western Alachua County, about 40 kilometers (25 miles) away from either site. A 69 kv line extends into Chiefland from the east. Cooling water for either site would be available from the Suwannee River. The average annual flow at Wilcox (immediately north of the town of Suwannee River) is 250,000 lps (8,800 cfs). The minimum daily flow for 17 years of record is 92,590 lps (3,270 cfs). The proposed power generating facilities would require less than 1 percent of this minimum flow.

Both potential sites are located on the Chiefland limestone plain, a flat rolling surface formed by erosion of Eocene limestone and leveled by deposition of fine argillaceous sand. The southern site includes several small intermittent ponds, suggesting sink holes; but the northern site lacks such features.

Aquatic vertebrates of special concern which have been reported in the Suwannee River are the following:

Endangered:	Florida manatee
	River redhorse
	American alligator
Rare:	Suwannee bass
Depleted:	Atlantic sturgeon.

The effects of the proposed power generating facilities on river and estuarine ecosystems would be limited by the fact that water withdrawals would average only about 0.35 percent of total river flow.

Construction of power plant facilities at the southern site might entail destruction of some freshwater marsh (6 percent of the site), cypress dome communities (14 percent of the site), and cypress-sweet gum-tupelo (13 percent of the site). Freshwater marsh is extensive throughout the surrounding area. The remainder of the southern site is covered by planted pine (43 percent of the site) and mesophytic hardwoods (22 percent of the site). The northern site lacks aquatic habitats and is covered by forest (of unknown composition) with some open fields. According to one siting report, the vicinity of the two Levy County sites could not be considered a typical wilderness habitat. Within the area there is hunting for white-tailed deer, grey and fox squirrels, wild hog, and rabbits. Levy County is included within the range of Florida panther (an endangered species), but this animal is not considered likely to occur at either site. No endangered species of birds are among the 99 known to occupy Manatee Springs State Park. However, two permanent residents, the American osprey and white ibis, are listed as "status-undetermined" species.

Old Town, site of one of the largest early Indian villages in Florida, lies on the west bank of the river about 5.6 kilometers (3.5 miles) northwest of the northern site. This is the nearest point of known historic or archaeological interest. Both sites are very close to Manatee Springs State Park which comprises 730 hectares (1,800 acres). The southern site borders Lower Clay Landing, a cluster of eight homes, and lies 2.4 kilometers to 3.2 kilometers (1.5 to 2 miles) north of Fowler Bluff, a concentration of about 50 buildings, most of them seasonal dwellings. There are several houses on the opposite bank.

The Suwannee River is used for sport fishing, commercial catfishing, and a dwindling sturgeon fishery industry. The river is also used for power boating and water skiing, and has been proposed both as a state canoe trail and as a federal Wild and Scenic River. On the whole, the sites on the Suwannee River would be among the most sensitive in terms of possible public and governmental reaction.

There are presently no major sources of air pollutants in the vicinity of the proposed sites, and the area is classified as Class II. Therefore, construction of new generating facilities should not cause a violation of NAAQS and should meet PSD increments under current conditions. However, if the area became a Wild and Scenic River and thus was shifted to a Class I area, the proposed facility might have to be limited in total capacity.

Crystal River

This site is located in Citrus County on the north shore of the Crystal River estuary about 110 kilometers (70 miles) north of St. Petersburg. The property is owned by Florida Power, which operates three existing power plants at the site: a 383 Mw oil unit, a 498 Mw coal unit, and an

825 Mw nuclear unit. The present oil unit (Crystal River Unit 1) is scheduled for conversion to coal in March of 1979. Unit 2 was converted to coal in December of 1976. All three existing units use once-through cooling with salt water. For the proposed new power generating facility, there are several theoretically possible sources of makeup water for cooling towers or ponds, which are described in the following paragraphs.

First, for freshwater makeup, wells could be drilled along the present power line rights-of-way. This alternative would require a water pipeline of about 9 kilometers (5.6 miles) in length.

Second, surface water could be withdrawn from the Crystal River or Lake Rousseau. Because Lake Rousseau appears preferable in terms of water quality, discharge, and avoidance of environmental impact, only Lake Rousseau has been considered in the latter stages of facility planning. Lake Rousseau was created by the construction of Inglis Dam across the Withlacoochee River in 1909. More recently, the lake was intended to be part of the Cross Florida Barge Canal. The section of the Canal between Lake Rousseau and the Gulf was constructed before the project was discontinued. The Canal cuts across the Withlacoochee River below Inglis Dam and reaches Lake Rousseau about 2.4 kilometers (1.5 miles) above the dam. Most of the flow of the Withlacoochee River is shunted through the lock. This arrangement leaves both the western area of Lake Rousseau behind Inglis Dam, and the section of the Withlacoochee River downstream from the dam, separated from the principal through-flow. Water withdrawals from behind the dam to serve the proposed new power generating facilities would increase flow substantially through the western arm of the lake, but would amount to less than 1 percent of the total flow of the Withlacoochee River.

Third, sea water could be used for once-through cooling, as in the present units. This step would require modification of existing intake and discharge canals.

Fourth, sea water could be used for off-stream cooling, such as cooling towers.

Fifth, the Barge Canal section below the Withlacoochee River could be utilized as a water source and possibly as a cooling pond. Using this source might involve construction of a salinity barrier and a gate to admit high flows from the Withlacoochee.

The Crystal River site is underlaid by a thin veneer of Pleistocene and Recent sediments over Inglis and Avon Park limestone. The groundwater table is at 3 meters (10 feet), and bedrock is encountered at 6 meters (20 feet). An existing network of vertical solution channels probably does not compromise the soundness of the rock. The site at which the proposed facilities would be located, to the northeast of the existing power generating units, presently consists of pine forest. There are some wet areas which should be avoided. It is considered unlikely that faunal species of special concern occur at the site, because of the highly altered state of the habitats present. However, bald eagles and ospreys are among birds observed on the site.

Facilities for barge delivery of coal are already present at the site. Without further maintenance dredging, the barge access arrangements would be somewhat limiting on the barge loads that could be handled. However, unloading capacity *per se* is more than adequate. The Crystal River site is presently served by both 230 kv and 500 kv transmission lines that extend east and south to the major urban centers of central Florida. These lines could easily accommodate the additional power loads generated by the proposed facilities. Crystal River is fairly well located relative to the load centers of Florida Power system.

The Crystal River site is favorable in terms of land use. Beyond the boundaries of Florida Power's holdings (which exceed 1,600 hectares or 4,000 acres) there are few sensitive land uses within several miles in any direction. The area consists primarily of wetlands, scrub, pasturage, planted pine, and some industrial land uses. The Crystal River site is considered especially favorable in terms of public acceptance of new power generation facilities.

There are two important considerations regarding air quality impact at the Crystal River site. First, the existing fossil-fuel plants at Crystal River predate the New Source Performance Standards and thus exceed the allowable sulfur dioxide emissions under these standards by a factor of five. Second, the Chassahowitzka Wilderness Area, located 21 kilometers (13 miles) south of the site, is now a Class I area with regard to air quality. These two factors may make it difficult for a new power generating facility to meet NAAQS and PSD requirements, unless the baseline air concentrations at Chassahowitzka are reduced (e.g., by substituting some low-sulfur fuel for high-sulfur fuel at the existing plants).

Anclote

The Anclote site is located in the extreme southwest portion of Pasco County on the north shore of the Anclote River estuary, 2 miles north of Tarpon Springs (population 11,951 in 1977). Five kilometers (3 miles) directly offshore are the Anclote Keys which include an undeveloped state park and a national wildlife refuge. Florida Power presently operates a 1,030-Mw facility at this site. Both of these facilities are oil-fired and utilize salt water for once-through cooling. Fuel is delivered to the site via pipeline.

The geology of the site involves 0 to 6 meters (0 to 20 feet) of unconsolidated sand overlying weathered limestone, with well-developed organic sediments occurring in scattered wet areas. Solution-collapse features are common. The site contains longleaf and slash pines and a xeric hardwood scrub. There are also limited areas of freshwater marsh and more mesic hardwoods. Saltwater marshes and mangroves are found along the coast. The area is heavily influenced by man and is considered unlikely to contain rare or endangered faunal species. However, bald eagles are among the birds seen near the site. Raccoons are much in evidence and may, perhaps, prevent the establishment of viable rookeries.

The principal advantages of the Anclote site for power generation are its proximity to the Pinellas County load center and its position within the existing transmission system. Its disadvantages involve water supply, land availability, and the presence of nearby urban development. Relatively little land would be available at the site without extensive condemnation proceedings. This fact, along with the existing stress upon freshwater resources in the vicinity of the site, would limit the available cooling options to saltwater cooling towers or once-through cooling. The latter would appear to be ruled out by the limited ability of the shallow waters in Anclote Anchorage to absorb additional heat loads, as well as by government policies.

Coal could potentially be brought to the site by either barge or rail. However, since barge docking and unloading facilities presently do not exist at the site, dredging would be required. The impacts of dredging and barge transportation on aquatic ecosystems could be significant.

The existing power generation facilities at Anclote are subject to New Source Performance Standards, so that the construction of a new facility would probably not cause a violation of either NAAQS or PSD air increments in the general vicinity of the plant. However, since the Anclote site is close to urban areas that are already subject to air quality stress (i.e., Pinellas County has been designated as a nonattainment area for sulfur dioxide), a new source could worsen existing air quality problems.

Phosphate Mining Site

The phosphate mine site under consideration is the 4,500 hectare (11,000-acre) International Minerals Corporation property located directly west of Homeland and approximately 8 kilometers (5 miles) southwest of Bartow (population 13,975 in 1977) in Polk County, Florida. The site has been selected in order to take advantage of land that has already been disrupted due to mining operations, for which the development of power generating facilities would, in fact, result in reclamation of the existing land. A power generating facility at this site would utilize sanitary wastewater from the City of Tampa's sewage disposal plant as cooling tower makeup water. A 64-kilometer (40-mile) pipeline costing roughly twenty million in current dollars would be required. Construction of this pipeline undoubtedly would involve some environmental impacts. On the other hand, the wastewater from Tampa would benefit water quality in the bay area as well as conserve freshwater resources inland.

The topography of the general area around the phosphate mining site is characterized by numerous depressions that are solution-related. However, geologic studies indicate that the underlying rock materials would be competent for support of heavy structures. The site has been highly altered by phosphate strip mining and agriculture so that almost no natural habitat remains. Of the total site area, 52.9 percent is pasture and cleared land of low natural fertility; 37.5 percent consists of abandoned mining areas with associated ponds and slime pits; 8.9 percent supports mesophytic hardwood growth, and 0.6 percent is citrus grove. The site formerly had been covered by pine flatwoods. The only game mammals known to occur on the site are marsh and cottontail rabbits. Game birds are limited to ducks, bobwhite quail, and mourning doves. Despite the large areas of pond and marsh habitat, the site is not an area of concentration for either doves or waterfowl (Florida Department of Natural Resources, 1971). The bald eagle, Florida grasshopper sparrow, and Florida burrowing owl are known to occur in the general vicinity of the site, but are considered unlikely to nest in such a highly disturbed area.

The phosphate mining site has very good highway and rail access, although there is no water access. A transportation alternative which might prove favorable is the barging of coal to Tampa, and rail shipment for the last 64 kilometers (40 miles). A backhaul arrangement could possibly be established involving outbound shipment of phosphate products. The location of the site is highly favorable with regard to the anticipated pattern of demand for power, and moderately favorable in terms of proximity to existing transmission corridors. There are no historic, scenic, cultural, or natural landmarks within the vicinity of the site, although the Peace River to the south has been designated as a Canoe Trail by the state. The site is rated highly in terms of: (1) the value of the land in question for alternative uses, which is low; (2) the nature of surrounding land uses; and (3) the overall degree of ecological impact that would be produced by power plant development.

Air quality would be a problem at the phosphate mining site because the area contains major industrial sources of TSP and SO_2, resulting in elevated ambient concentrations. Violations of NAAQS for TSP have been observed. The vicinity of the site has been designated an Air Quality Maintenance Area for TSP and SO_2 by the Florida Department of Environmental Regulation, so that special review is required for new sources. Although the exact situation cannot be known without detailed study, it appears that the proposed facility might cause or contribute to NAAQS violations unless extra controls were implemented. Also, the air quality increment for Class II might not be available for the facility.

Lake Jessup

The Lake Jessup site is located in Seminole County on the southeastern shore of Lake Jessup, about 4 kilometers (2.5 miles) north of Oviedo and 19 kilometers (12 miles) northeast of Orlando. This site has been included here due to the desirability of an alternative in the Orlando area which would utilize municipal wastewater for cooling system makeup. Relatively little information is available for the Lake Jessup site, or for the possibility of utilizing municipal wastewater in this case. The City of Orlando operates two 30 mld (8 mgd) sewage treatment plants whose combined flow would fall somewhat short of the cooling water makeup requirements of the proposed facilities (although the shortfall might be small by 1984). Orlando wastewater might, therefore, have to be supplemented by water from other municipal treatment plants, from

Lake Jessup, or from other sources. The costs and environmental impacts associated with piping Orlando wastewater to the Lake Jessup site are uncertain at the present time.

The Lake Jessup site under consideration is composed of land parcels owned by as many as 40 different individuals. The site contains orange groves and truck farms, along with limited areas of marsh and scrub forest. There are a small number of existing residences. The area surrounding the site is generally rural in character, but has a moderately high population density. Most of the site itself is well drained and contains dark soils of high organic content. Unlithified sediments of the Fort Preston Formation are exposed on the site, and there are peat deposits of unknown thickness. Structural contours on geologic maps indicate that Eocene limestones lie at 23 to 30 meters (75 to 100 feet) beneath the surface. Deep foundations would probably be required for construction of the proposed power generating facilities.

An existing bituminous road runs along the southern edge of the property. Railroad service is presently available only at Ovido, about 4 kilometers (2.5 miles) to the south, but a dismantled spur right-of-way reaches the southern edge of the site. It appears unlikely that barging of coal to the site via Lake Jessup would be feasible, due to limited depth and other constraints.

The probable impacts of the proposed project at Lake Jessup upon water, land, and air resources are relatively unknown. The project, if sited carefully, should have only limited effects upon terrestrial fauna and flora because most of the land has been altered from natural conditions for agricultural use. The loss of prime agricultural land would be a significant impact in itself, however. Water quality in Lake Jessup would be a serious concern; and extensive hydrological studies would be required to prevent either alteration of hydroperiod or contamination of ground water. The site is only 2.4 kilometers (1.5 miles) from the Econolockhatchee River, which has been designated as a State Canoe trail. However, the site is not within the surface drainage basin of this water body. Regarding air quality, the Lake Jessup site is perhaps as favorable as any of the other alternatives discussed here, because of the absence of industrial emissions or Class I areas in the immediate vicinity.

DeBary

The DeBary site is located on the east bank of the St. Johns River in Volusia County near the town of DeBary. Other nearby communities are Orange City, Deltona, and Deland. Since 1976, Florida Power has operated a 336 Mw combustion turbine plant at the site, and more than 1,250 Mw of additional generating capacity is located in the vicinity. The land area at the site consists of sandy hills and some freshwater marsh underlain by limestone. Secondary and remnant channels of the St. Johns River dissect the eastern portion of the site, and there are some surface depressions due to solution activity. The area immediately surrounding the 810 hectare (2,000 acre) site consists of sandy hills and stands of slash pine, with very little developed land.

The primary vegetative associations at the DeBary site, in order of importance, are sand pine scrub, brush flatwoods, brush swamp, prairie, mesophytic hardwoods, and freshwater marsh. The existing fauna in the vicinity of the site are known to include more than 41 species of mammals, 192 species of birds, 33 species of amphibians, and 58 species of reptiles. The presence of rare or endangered species has not been determined. A 1973 study by the State of Florida found no significant archaeological or cultural resources at the site proper, although two potentially important sites were identified at the south end of Pine Island which would require further examination. The Wekiva River, a state Canoe Trail, enters the St. Johns River 1.6 kilometer (1 mile) below the site; and Huntoon Island State Park is 3.2 kilometers (2 miles) downstream.

The DeBary site is potentially favorable in terms of transportation, since a rail line crosses the property. Barge access is possible via the St. Johns River, although construction of barge terminal facilities would require substantial dredging. The barge traffic generated by the proposed power generating plant might also create navigational problems on the river due to the volume of existing traffic. A significant disadvantage of the site is that a substantial area is subject to flooding under extreme conditions.

The DeBary site is well-situated relative to the anticipated future power needs within Florida Power's service area. No new transmission corridors would be required. The size of the site would permit the use of either cooling towers or cooling ponds. On the other hand, the site is questionable in terms of water supply, wastewater disposal, and air quality degradation. Water quantity and quality have become serious issues in the St. Johns River basin. The long-term average discharge of the St. Johns is 85,000 lps (3,000 cfs), and the average for the driest month (May) is 51,000 lps (1,800 cfs). However, the lowest monthly flow of record is only 1,980 lps (70 cfs). Withdrawals by the proposed facilities for cooling water makeup could therefore approach one-third of discharge on rare occasions.

Disposal of wastewater from the power plant operations into the St. Johns could be unacceptable because of the recreational use of the river in this vicinity. Evaporation/percolation ponds could pose a threat to groundwater supplies, due to the permeability of the limestone substrate and the fact that recharge to the Floridan aquifer occurs at the site. Finally, ambient air quality near the site is likely to be degraded due to the existing power plants in the area.

Palatka North and Palatka South

Two sites in Putnam County near the City of Palatka (population 9,271 in 1977) are discussed here, one about 8 kilometers (5 miles) northeast of

Palatka and one approximately 5.6 kilometers (3.5 miles) southeast of the city. Both sites front on the St. Johns River. These sites are outside Florida Power's service district, but are less distant from the primary areas to be served than several of the other alternatives under consideration. The major advantages of these sites are that direct barge access to East Coast ports would be possible via the St. Johns River (control depth 4 meters or 13 feet), and that rail delivery from points outside Florida would be less costly than for any of the other alternatives.

The Palatka North site consists primarily of a large dairy farm. The adjacent land is pine woods with a large cypress dome directly to the west. Some cypress occurs on the site, but only in a few low areas. A significant land use problem is the fact that the riverfront near the site is lined with upper-income homes. The Palatka South site is primarily forested with some open fields and marshy areas. Nine houses and a boat ramp at Stokes Landing presently exist on the site. Deep foundations would probably be required for construction of the proposed facilities at the Palatka South site. Undifferentiated Pleistocene and recent deposits overlie older deposits, and Eocene limestones begin at about the 60 meter (200 foot) depth.

Both the Palatka North and Palatka South sites would be served by the Seaboard Coastline Railroad, with 3.2 to 4.8 kilometer (2 to 3 mile) rail spurs required in each case. A significant factor in terms of cost and environmental impact is that a transmission corridor exceeding 64 kilometers (40 miles) in length, and probably another shorter corridor, would be required in order to link either site to Florida Power's existing transmission system. The flows in the St. Johns River are probably adequate for its use as a source of cooling system makeup water, although salinity and entrainment of aquatic life might pose problems. The possibility of water quality and thermal impacts as a result of power plant operation would have to be studied carefully.

The only existing major source of air emissions near the Palatka North site is the Hudson Pulp and Paper Company facility west of Palatka. However, the Seminole Electric Cooperative plans a 600 Mw coal-fired power plant at a location near Bostwick. This expansion may consume PSD increments that otherwise would be available for the Florida Power facilities. In addition, there might be a possibility of NAAOS violations. With regard to the Palatka South site, the Hudson and Seminole emissions would be more distant, but air quality would be affected by a 580 Mw combined cycle facility operated by Florida Power and Light Company at a nearby location. Thus, NAAOS would also have to be examined closely in this case.

COST COMPARISON OF ALTERNATIVE SITES

The total cost of providing electrical service is no longer the only criterion considered in power plant siting and design. Government regulations and policies aimed at minimizing environmental impacts, along with growing awareness of these concerns on the part of the public and the industry, have created a situation in which many factors can override cost considerations. However, close attention must obviously be paid to cost in order to establish site feasibility.

Table 8.3-4 presents a summary cost comparison of all the sites discussed above, with the Crystal River site as a base. All costs are presented as increments relative to the corresponding cost for the Crystal River site (with negative increments written in parentheses). Three major categories of cost are considered, on an annualized basis: power transmission, fuel delivery, and cooling. Most of the omitted elements, such as site acquisition and site development costs, would not affect significantly the outcome of the comparison. However, an excluded element which could have a major bearing on the comparison is the existence of cost differentials due to different air emission control requirements at the various sites. (This factor is discussed later). The data are necessarily quite rough because a large number of uncertainties are involved.

Table 8.3-4. Comparative Costs for Power Plant Site Alternatives: Increment Costs Relative to Crystal River Site (Millions of Dollars)

	Transmission	Fuel Delivery	Cooling	Total
Gulf County	26	8-10	(10)	24-26
St. Marks	11-14	4-5	0	15-19
Levy County (2 sites)	7-9	0	0	7-9
Crystal River	0	0	0	0
Anclote	2	3-4	0	5-6
Phosphate Mining Zone	(3)	4-5	4	5-6
Lake Jessup	2	0	3-4	5-6
DeBary	0	0	0	0
Palatka North	9-10	(1-2)	0	7-9
Palatka South	8-9	(1)	0	7-9

Note: Numbers in parentheses are negative quantities.

Sources: Florida Power Corporation, 1977.
Environmental Science and Engineering, Inc., 1977.

The transmission cost element covers both the required investment in new transmission facilities, on an annualized basis, and the anticipated line transmission losses. An average cost of $550,000 per mile of new transmission corridor is assumed; but actual costs obviously could deviate from this figure depending upon the conditions encountered. The valuations placed on the transmission losses are based upon estimates of future demand for power in each of the five major regions served by Florida Power.

Fuel delivery is potentially a very important cost element and is perhaps the factor that involves the greatest degree of uncertainty. The findings of fuel supply studies have indicated that it is adequate to conduct cost comparisons of alternative sites using the assumption that all coal shipments, amounting to 4,000,000 tons (3,600,000 metric tons) per year, will be by rail. The availability of water transportation thus is not reflected in the cost comparisons shown in Table 8.3-4. However, water access is treated qualitatively as a "plus" for the following sites:

Full Water Access Advantage

Gulf County
Crystal River
Palatka (North and South)

Partial Water Access Advantage

St Marks
Levy County (2 sites)
Anclote
Phosphate zone
DeBary

The sites listed as having a partial advantage are cases in which reliance upon barge transportation could be problematic, due to: dredging requirements (St. Marks, Anclote, and DeBary); the existing volume of barge traffic (DeBary); or other anticipated impacts. The phosphate zone site is also included because of its potential for barge/rail shipments involving deep-draft barges to Tampa.

Regarding rail transportation, the prevailing rate structure is such that all shipments to Florida are charged as if they pass through Jacksonville, whether or not this is actually the case. Three representative rates for coal shipments from Eastern Kentucky are the following:

to Crystal River: $17.37/ton
to Bartow (phosphate zone): $18.53/ton
to Port St. Joe: $21.98/ton

The cost comparisons in Table 8.3-4 assume that cooling towers would be utilized at all of the alternative sites except Gulf County, in which case there would be once-through cooling. Cooling tower makeup water would necessarily be fresh water except possibly at the Gulf County, Crystal River, and Anclote sites. Cooling ponds could potentially be substituted for towers at several of the sites; but this might produce only limited savings, due to the precautions which would be required in constructing and operating the ponds. The only nonzero cost increments for cooling other than at the Gulf County site are for the two cases in which municipal wastewater effluent would be the primary source of cooling tower makeup water. The use of treatment plant effluent would involve an increment of approximately one million dollars in operating costs, in addition to the costs associated with pipeline construction.

The total increments shown in the last column of Table 8.3-4 indicate that the Crystal River and DeBary sites are most favorable in terms of cost, and that the Gulf County and St. Marks sites are by far the least favorable because of their distance from major load centers served by Florida Power and the existing power transmission system. The overall cost comparisons presented in Table 8.3-4 suggest a categorization of the sites into the following four groups:

SITE RATINGS ACCORDING TO COST*

Unacceptable
- Gulf County
- St. Marks

Marginal
- Levy County (2 sites)
- Palatka North
- Palatka South

Moderately Favorable
- Anclote
- Phosphate zone
- Lake Jessup

Highly Favorable
- Crystal River
- DeBary

*Excluding differential costs due to air emission controls.

The group containing Gulf County and St. Marks has been termed "unacceptable" because the cost increments for these sites relative to Crystal River would amount to more than 10 percent of the total annual project costs at the latter location. Sites in the "marginal" category remained eligible for consideration if they were especially favorable in other respects. As for sites in the "moderately favorable" and "highly favorable" cost categories, the differences between these in terms of cost have been considered less important than distinctions involving environmental impact and social acceptance.

AIR QUALITY COMPARISON OF ALTERNATIVE SITES

The factors affecting the degree of air emission control required at the alternative sites have already been discussed on an individual basis. These factors could not be included in the cost comparisons without detailed studies to determine the emission controls required in each case. However, Table 8.3-5 presents a summary evaluation of the sites in terms of the probability that the proposed power generating facilities

Table 8.3-5. Air Quality Constraints for Alternative Sites

Probability of Approval Without Additional Cost	Site	Probable Magnitude of Additional Cost Required To Meet NAAQS and PSD
80% or Better	Levy County (2 sites) Lake Jessup	None
50% - 65%	Gulf County Palatka South DeBary	None
0% - 20%	Anclote Palatka North	Small
0%	St. Marks (Wakulla Co.) Crystal River Phosphate Zone (Polk Co.)	Small to Large

Source: Environmental Science and Engineering, Inc., 1977.

could be approved at a given site without additional expenditures beyond the level required to comply with New Source Performance Standards and Latest Reasonable Available Control Technology. These judgments are necessarily subjective, but are based on all available information regarding air quality and applicable standards.

Table 8.3-5 shows that air emission control requirements could reduce or negate some of the cost differences noted earlier, in particular the cost advantage of the Crystal River site and the disadvantages of the "marginal" sites (the Levy County and Palatka alternatives). The extent of these offsetting effects is relatively uncertain, however.

FURTHER SCREENING OF SITE ALTERNATIVES

The two most remote site locations, relative to Florida Power's service area, were eliminated from further consideration on the basis of cost differentials. The group of sites ranking next in terms of remoteness and comparative cost, namely the locations in Levy County and the sites near Palatka, also lacked sufficient compensating factors to warrant further consideration. A major disadvantage in terms of environmental impact is that new transmission corridors would be required for all four of these sites, with the total length possibly exceeding 97 kilometers (60 miles) for the Palatka alternatives.

The Palatka North site would tend to involve land use conflicts and site acquisition problems. Site development could pose difficulties at South Palatka. Surface water quality would be a serious issue in both cases due to the recreational use of the St. Johns River and the commercial fisheries operating in the area. With regard to Levy County, the sites on the Suwannee River would be generally unfavorable given the strong local sentiment in support of preserving natural amenity and water quality, and the resulting controversy that would be generated by any new major power plant project.

The Anclote site was judged to be inferior to other alternatives with comparable cost characteristics, despite its favorable location within Florida Power's service area, because of the limitations of the site land, the proximity of urban development, and the lack of satisfactory cooling arrangements.

Regarding the Lake Jessup site, the possibility of a power generating facility near Orlando which utilizes municipal wastewater for cooling system makeup could be favorable in terms of both water conservation and efficient coverage of Florida Power's service area. However, this alternative has been considered less desirable, on balance, than the phosphate zone alternative, which would also utilize municipal wastewater. Population density in the area surrounding the Lake Jessup site is moderately high, and there are some residents at the site itself. Unlike the phosphate mining site, land acquisition could be difficult since the land involved is parceled among as many as 40 owners. Conversion of the Lake Jessup site to power generation use would displace valuable existing uses (citrus groves and truck farming). Although neither the Lake Jessup site nor the phosphate mining site would have barge access, the barge/rail arrangements possible for the phosphate mining site would be considered a plus. The Lake Jessup site is better than the phosphate mining site in terms of air quality. The extra emission controls required in the latter case could create an appreciable difference in total project costs. On the other hand, the availability of an adequate volume of cooling water could be questionable for Lake Jessup. Overall, the phosphate mining site has been considered preferable to Lake Jessup because of greater public acceptability and land use compatibility.

FINAL SITE SELECTION

The three most favorable site alternatives for new generating facilities are Crystal River, DeBary, and the phosphate mining property. These sites differ in a number of fundamental respects, so that the outcome of any comparison is dependent upon the relative importance assigned to specific factors. As indicated earlier, the cost differentials for these sites are not critical; the greatest weight should instead be given to environmental impact and resource conservation issues. In order to summarize these issues, Table 8.3-6 shows in very simple outline the most serious liabilities associated with each site. The four categories of environmental impact considered are water supply, wastewater discharge, ambient air quality, and terrestrial ecology. It is not necessary at this point to consider impacts which are essentially similar for the three sites, or which are of secondary importance (for example, the effects of a facility at DeBary on navigation in the St. Johns River).

The issue of water supply for cooling system makeup is considered critically important. Consequently, the option of utilizing saltwater cooling towers at Crystal River is considered as a separate alternative in Table 8.3-6, since this option has major implications for water supply impact.

Water supply would not constitute a liability for the phosphate zone site or for the Crystal River site with off-stream saltwater cooling. Power generating facilities at the phosphate zone site would utilize municipal wastewaters that otherwise would have zero or negative ecological value (when discharged into Hillsborough Bay). The use of salt water at Crystal River would not represent consumption of a limited resource. Also, the location of the intake in the existing discharge canal for Crystal River Units 1, 2, and 3 would limit entrainment/impingement problems. On the other hand, water supply would represent a very serious liability at DeBary, and could be serious at Crystal River with freshwater cooling. Numerous public agencies and water management districts in Florida have questioned the wisdom of utilizing the state's limited freshwater resources for power plant cooling purposes, given the potential availability of salt water. Water supply and water quality are particularly critical issues in the St. Johns River basin where the DeBary site is located.

Table 8.3-6. Summary of Liabilities Associated with the Three Most Favorable Sites

Facility Site	Water Supply	Wastewater Supply	Ambient Air Quality	Terrestrial Ecology
DeBary	X	X		
Phosphate zone		X	X	(X)
Crystal River (with fresh-water cooling)	X		X	
Crystal River (with salt-water cooling)			X	

Source: Environmental Science and Engineering, Inc., 1978.

Disposal of cooling system blowdown water and other wastewaters from power plant operation would present for fewer problems at Crystal River than at the other two sites, because of the direct discharge to the Gulf of Mexico and the very high degree of dilution received in the Crystal River discharge canal. Wastewaters discharged at DeBary and at the phosphate zone site could affect extensive river systems (St. Johns River and the Peace River, respectively). The contaminants introduced by the use of municipal wastewater could present special problems at the phosphate zone site, whereas discharges at the DeBary site could be opposed due to the intensive recreational use of the St. Johns River. Groundwater contamination would be a possibility in either case if evaporation/percolation ponds were utilized.

None of the three sites is highly favorable in terms of air quality impacts, but the DeBary site is clearly best in this regard. The addition of new facilities at Crystal River would require special measures to meet NAAQS and PSD requirements, given the proximity of the site to the Chassowitzka Wilderness Area. At the phosphate mining site, the existing air quality degradation in the vicinity could make the licensing of new power generating facilities questionable. (The air quality increment for Class II might not be available.) This site could well be the worst in terms of air quality.

In a general sense, the regions surrounding the Crystal River and the Polk County phosphate mine plant site alternatives contain the same floral and faunal assemblages. One hundred and sixteen plant species have been identified on the Crystal River site (ESE, 1977), while a similar study in the region of the phosphate mine site found 144 species (CF Development Corporation 1976). Table 8.3-7 shows the number of animal species expected to be found near each site. It can be seen that both regions have similar faunal diversities and that both have similar numbers of rare or endangered species.

Table 8.3-7. Number of Faunal Species Found in Polk and Citrus Counties

	Polk County	Citrus County
Mammals	42 (8)*	47 (10)
Birds	306 (32)	274 (24)
Reptiles	57 (7)	69 (5)
Amphibians	24 (1)	36 (3)

* Numbers in parentheses refer to number of species on the list of the Florida Committee on Rare and Endangered Plants and Animals (1977).

Sources: Archbold Biological Station, 1977.
Environmental Science and Engineering, Inc., 1977.

Of the 426 animal species which may be found on the Crystal River site, 107 were sighted during a three-day survey in August 1977 (ESE, 1977). Such a large species diversity is not unusual, considering the interspersion of several habitat types on this site. The community types on this site include pine flatwoods, evergreen oak scrub, freshwater marsh, ruderal transmission corridors, pine plantation, mesic hammock, hydric hammock, coastal hydric hammock, coastal hammock, and salt marsh. The ruderal and flatwoods areas here are in early succession states and consequently are not unique or of great value. The hammock areas, on the other hand, do contain large old-age trees, and represent mature complex systems. This is especially true of the coastal hydric hammock.

According to the Florida Power 1978 Ten-Year Site Plan, about one-third of the mine site consists of mined lands. About one-half of the area is pasture and cleared land, about 10 percent in hardwoods, and 1 percent in citrus. Due to its low diversity of habitat, its cleared expanses, and its industrial activity, this site would be expected to contain a much lower diversity of wildlife than is present. Some adaptive species such as quail, mourning dove, and eastern cottontail rabbit are abundant. Isolated or perched freshwater marshes, which usually constitute about 20 to 30 percent of the natural flatwoods in the region, are found on the site. Their precise extent would depend on how much of the pasture constitutes relaimed land. In any event, the wildlife value of the marshes would probably be considered relatively low because of the altered nature and the depression of the water table in the region.

Reclaimed areas do, however, have high potential as wildlife habitat, especially around the old mine pit lakes (Archbold Biological Station, 1977). Rare or endangered species which are found here include the Florida sandhill crane, Audubon's caracara, and many wading birds. The area would have less potential for rare and endangered reptiles and amphibians.

The phosphate mine is within two miles of the Peace River. Drainage from the site historically went to this river through two creeks which have since been altered by mining. Drainage from the western portion of the site at one time went to Hookers Prairie and the South Prong of the Alafia River, but adjacent mining has altered this as well. The only significant hardwoods on the site are remnants of a creek bottom mixed swamp or bayhead which has since been largely isolated.

The alternative site in Polk County would probably present a lesser impact on wildlife and mature or unique natural ecosystems than would the Crystal River site. However, off-site impacts might counteract this advantage to some extent. Such impacts could result from effects of seepage, spills, or air emissions on the Peace River and its floodplain vegetation, construction of pipelines to bring water to the site from as far away as Tampa, and construction of new transmission systems to tie in with existing lines as far away as Lakeland. Pipeline and transmission corridors could thus alter more habitat than the site itself. Proper alignment of such corridors could, however, result in minimal habitat disruption by crossing primarily pasture and rangeland areas.

The construction of power generating facilities would involve roughly similar on-site impacts at Crystal River and DeBary. As indicated above, the phosphate mining site would be preferable in this regard given the presently disrupted condition of the land. However, the most critical element in the comparison of sites is the existence of off-site impacts. In contrast to the Crystal River and DeBary sites, which would not require new corridors for water or power transmission, the phosphate zone alternative would involve construction of a 64-kilometer (40-mile) pipeline and a new power transmission corridor exceeding 8 kilometers (5 miles) in length. Since the routing of these facilities is unknown, their terrestrial impacts are uncertain, but the extent of ecosystem disruption could be very substantial.

The conclusion from the site evaluation is that the Crystal River site with saltwater cooling towers is the most favorable alternative. The fact that fewer air quality problems are expected at DeBary is more than offset by the avoidance at Crystal River of serious environmental problems involving water supply and wastewater disposal. Relative to the phosphate mining site, the Crystal River site with saltwater cooling is clearly advantageous in terms of wastewater disposal, ecosystem preservation, and the saving of five million dollars or more per year. However, the phosphate zone site will be considered as a potential location for power generating facilities in the future.

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9.0 PLANT DESIGN ALTERNATIVES

9.1 INTRODUCTION

This chapter presents plant design alternatives in the following categories:

- Plant location and layout
- Coal handling systems
- Water source and intake alternatives
- Cooling alternatives
- Atmospheric pollution control alternatives
- Wastewater discharge alternatives
- Solid waste disposal alternatives
- Transmission facilities

Discussion is in order according to energy and materials flow through a generalized power generating facility. The categories are grouped as either Input or Output Systems as shown conceptually in Figure 9.1-1. Input systems are those which bring essential materials and energy to the power plant proper, and output systems are those which handle the electrical power output and other by-products of power generation such as waste heat, waste water, and solid waste. The input and output systems discussed here are essential, but auxiliary, to the actual power generating structure. The design of the electrical generating system of the plant is not included as a design alternative.

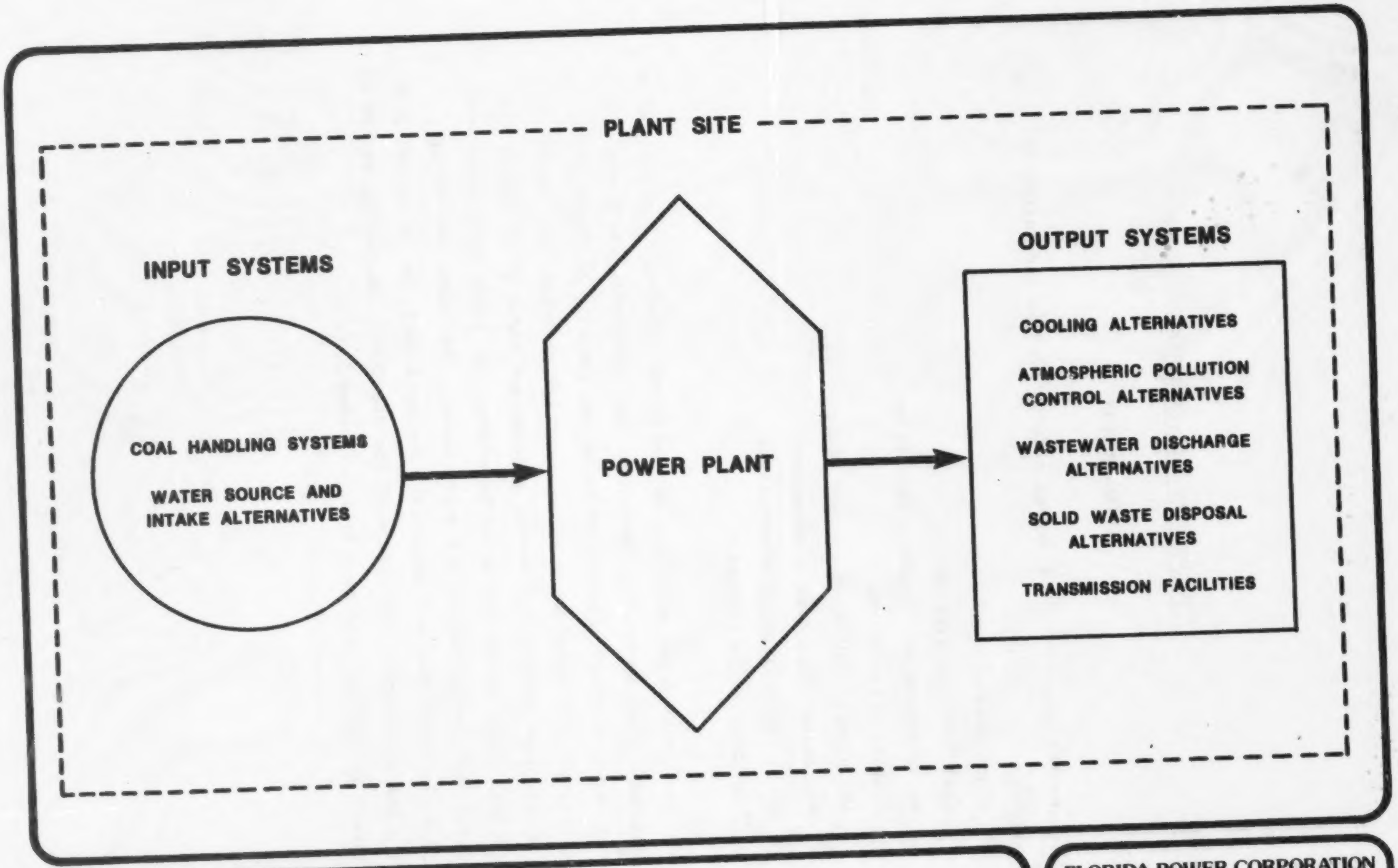
PLANT SITE
INPUT SYSTEMS
COAL HANDLING SYSTEMS
WATER SOURCE AND INTAKE ALTERNATIVES
POWER PLANT
OUTPUT SYSTEMS
COOLING ALTERNATIVES
ATMOSPHERIC POLLUTION CONTROL ALTERNATIVES
WASTEWATER DISCHARGE ALTERNATIVES
SOLID WASTE DISPOSAL ALTERNATIVES
TRANSMISSION FACILITIES

Figure 9.1-1
CONCEPTUAL DIAGRAM OF ALTERNATIVE SYSTEMS

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1978

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

9.1.1 GENERAL OBJECTIVES

The purpose of this section is to summarize design alternatives for auxiliary systems of proposed power generating units 4 and 5 at Crystal River, Florida. Alternatives considered in each of the auxiliary systems categories are those in operation at power plants throughout the country, or those which exist at the forefront of technology, but might be shown to be feasible in the future.

Several standards and criteria serve to reduce the number of alternatives initially addressed to the final number of alternatives considered: state and federal standards for all air and water quality impacts, public policies, engineering, social and ecological values, and economics of public service.

A comparative analysis of economic, technical, and environmental considerations is offered at the end of each systems category as a basis for guiding decisions as to which alternatives are preferred. This effort does not select a final alternative in any category but serves to provide the decisionmaker with the necessary information to make the final choices.

9.1.2 EVALUATION CRITERIA FOR ALTERNATIVE SYSTEMS

ECONOMIC CRITERIA

Economic evaluations were developed for a single generating unit (Unit 4). Evaluations for a second generating unit (Unit 5) can be developed by appropriate adjustment of the Unit 4 criteria. Commercial operation of Unit 4 is scheduled for October, 1982. The evaluation period for Unit 4 will be 30 years beginning in October, 1982, and ending in September, 2012.

Estimates of capital costs for Unit 4 were developed in constant (1977 or 1976) dollars as noted without considering the effects of inflation. Costs for alternative flue gas scrubbers and associated equipment, cooling towers, and common facilities which could be prorated to a second unit, if constructed, will be shown separately in all estimates. The annual fixed charge rate on the plant investment is 17.0 percent for 1976 studies and 14.0 percent for 1977 studies. The present worth discount rate is 12.0 percent for 1976 and 11.0 for 1977 studies.

Construction overhead, including interest during construction, financing, and administrative costs was estimated to be 25 percent. Escalation rates for price inflation are 7 percent per year compounded monthly to the anticipated date of delivery for equipment and materials, and 7 percent per year compounded monthly to the midpoint of the anticipated construction period for field construction. When capital costs for specific items are expected to deviate significantly in escalation from the above average, the escalation factors will be adjusted accordingly, with a notation about the cause made in the estimate.

Escalation was calculated only for the project estimate and will be separately stated as an adjustment to the constant dollar base costs of equipment and construction. Escalation will not be calculated for system studies except as required for annual cost analyses.

Load Model--New Units

The load model for purposes of siting studies is shown on Table 9.1-1.

Load Model--Existing Units

The load model of the existing coal-fired units (Crystal River Units 1 and 2) is shown on Table 9.1-2. The load model will be utilized for site related studies involving facilities common to a four unit plant (cooling water, coal delivery and storage, ash and rejects generation, etc.).

Fuel Costs

The fuel costs of coal are projected as shown on Table 9.1-3 for the first 7 years of operation. Fuel costs after 1988 are assumed to escalate at the rate of 5.0 percent per year (annually compounded) for the remaining plant life.

Capacity Cost

The capacity costs for 1982 commercial operation has been established at $450 per kw for 1976 studies and $480 per kw for 1977 studies (System Basis Average) and $300 per kw (Incremental Basis). System basis capacity costs are assumed to escalate at the rate of 7.0 percent per year (annually compounded) for the new plant, base load generation additions.

Energy Cost

The energy costs consist of a portion for fuel costs and a portion for operating and maintenance costs. The projected energy cost for the 30-year evaluation period is shown on Table 9.1-4.

Table 9.1-1 Load Model for Each Proposed Unit, Crystal River Units 4 and 5

Net Plant Output (Mw)	Hours of Operation				
	1982-1986	1987-1991	1992-1996	1997-2001	2002-2012
660-600	1,300	1,300	1,100	800	600
600-540	4,000	4,000	3,700	3,400	3,000
540-480	700	700	600	600	600
480-420	300	300	200	200	200
420-360	200	200	200	200	200
360-300	100	100	200	200	200
300-120	600	600	800	800	700
Total Hours On-Line	7,200	7,200	6,800	6,200	5,500
Average Output While On-Line	0.88	0.88	0.85	0.84	0.84
Annual Capacity Factor*	0.72	0.72	0.66	0.59	0.52
Average Output While On-Line Over Operating Lifetime*				0.855	
Average Annual Capacity Factor Over Operating Lifetime*				0.624	

*Capacity Factor and Output based on 660 Mw net expected capability.

Source: Black and Veatch, 1976.

Table 9.1-2 Combined Load Model for Existing Crystal River Units 1 and 2

Percent Capacity	Net Plant Output		Hours of Operation/Year				
	Unit 1	Unit 2	1977-1981	1982-1986	1987-1991	1992-1997	1997-2001
	Mw	Mw					
100	379	491	800	700	300	200	200
100-90	379-341	491-442	3,900	3,300	2,100	1,300	1,300
90-80	341-303	442-393	1,000	1,100	2,000	2,200	2,200
80-70	303-265	393-344	700	700	1,000	1,400	1,400
70-60	265-227	344-295	400	600	700	800	800
60-50	227-189	295-246	400	500	500	600	600
Total Hours On-line			7,200	6,900	6,600	6,500	6,500
Average Output While On-line			.88	.86	.83	.80	.80
Annual Capacity Factor			.72	.68	.63	.59	.59
Average Output While On-line Over Operating Lifetime						0.84	
Average Annual Capacity Factor Over Operating Lifetime						0.65	

Source: Black and Veatch, 1976.

Table 9.1-3 Fuel Costs of Coal

Year	Fuel Costs ($/M Btu)
1982	2.20
1983	2.31
1984	2.43
1985	2.55
1986	2.67
1987	2.81
1988	2.95

Source: Black and Veatch, 1976.

Table 9.1-4 Energy Costs

Year	Present Worth Factor*	Energy Charges			Present Worth of Energy Costs ($/kwh)
		Fuel † ($/kwh)	Operating** ($/kwh)	Total ($/kwh)	
1982	0.8929	0.02046	0.00138	0.02184	0.01950
1983	0.7972	0.02148	0.00149	0.02297	0.01831
1984	0.7118	0.02256	0.00160	0.02416	0.01720
1985	0.6355	0.02368	0.00174	0.02542	0.01615
1986	0.5674	0.02487	0.00188	0.02675	0.01518
1987	0.5066	0.02611	0.00203	0.02814	0.01426
1988	0.4523	0.02742	0.00219	0.02961	0.01339
1989	0.4039	0.02879	0.00237	0.03116	0.01259
1990	0.3606	0.03023	0.00256	0.03279	0.01182
1991	0.3220	0.03174	0.00276	0.03450	0.01111
1992	0.2875	0.03333	0.00298	0.03631	0.01044
1993	0.2567	0.03499	0.00322	0.03821	0.00981
1994	0.2292	0.03674	0.00348	0.04022	0.00922
1995	0.2046	0.03858	0.00376	0.04234	0.00866
1996	0.1827	0.04051	0.00406	0.04457	0.00814
1997	0.1631	0.04253	0.00439	0.04692	0.00765
1998	0.1456	0.04466	0.00474	0.04940	0.00719
1999	0.1300	0.04689	0.00511	0.05200	0.00676
2000	0.1161	0.04924	0.00552	0.05476	0.00636
2001	0.1037	0.05170	0.00597	0.05767	0.00598

Table 9.1-4 Energy Costs (Continued, page 2 of 2)

Year	Present Worth Factor*	Energy Charges Fuel † ($/kwh)	Energy Charges Operating** ($/kwh)	Energy Charges Total ($/kwh)	Present Worth of Energy Costs ($/kwh)
2002	0.0926	0.05429	0.00644	0.06073	0.00562
2003	0.0826	0.05700	0.00696	0.06396	0.00528
2004	0.0738	0.05985	0.00752	0.06737	0.00497
2005	0.0659	0.06284	0.00812	0.07096	0.00468
2006	0.0588	0.06599	0.00877	0.07476	0.00440
2007	0.0525	0.06928	0.00947	0.07875	0.00413
2008	0.0469	0.0725	0.01022	0.08297	0.00389
2009	0.0419	0.07639	0.01104	0.08743	0.00366
2010	0.0374	0.08021	0.01193	0.09214	0.00345
2011	0.0334	0.08422	0.01288	0.09710	0.00324
2012	0.0298	0.08843	0.01391	0.10234	0.00305

Present Worth Factors = 8.0850

* Present worth discount rate of 12.00 percent per year.

† Fuel costs shown are based on a projected net plant heat rate of 9,700 Btu/kwh.

** Operating and maintenance costs escalated at 8 percent per year--compounded.

Source: Black and Veatch, 1976.

Temperature Data

Wet bulb and dry bulb air temperature data and ambient inlet water temperature data used in development of cost estimates are presented in Tables 9.1-5 and 9.1-6, respectively.

Table 9.1-5 Average Monthly Temperatures

Month	Dry Bulb* (°F)	Wet Bulb † (°F)
January	61.4	55
February	63.3	58
March	63.7	62
April	69.8	66
May	76.2	71
June	78.9	74
July	79.3	75
August	79.0	75
September	76.8	74
October	73.0	69
November	63.7	63
December	56.8	57
Annual	69.0	67

Note: The above data on dry bulb and wet bulb temperatures are for different years and cannot be compared directly. However, these data are not used simultaneously in this study and are considered representative for the uses made of the data.

* Source: Crystal River Site, 1975 Meteorological Data.

† Source: Black & Veatch Report to Florida Power Corporation entitled Cooling Channel for Crystal River Plant, dated October 1, 1971.

Table 9.1-6 Mean Inlet Water Temperatures

Month	Mean Temperature °F
January	57
February	62
March	65
April	75
May	79
June	84
July	85
August	85
September	83
October	75
November	66
December	60

Source: Crystal River Unit 3 Environmental Report.

9.2 PLANT SITING, LOCATION, AND LAYOUT ALTERNATIVES

9.2.1 OBJECTIVES

Alternatives were considered in this subsection at three levels: plant siting, location on the site, and layout of the facility. For purposes of this discussion, "location" refers to the placement of the facility within a specific area on FPC property at Crystal River. "Layout" refers to the arrangement of the various components (cooling towers, turbine buildings, roads, etc.) within a particular "location." "Siting" refers to the placement of the facility within a larger geographical area and is discussed more thoroughly in Chapter 8 of this document.

9.2.2 EVALUATION CRITERIA

SITING CRITERIA

Siting of the proposed power plant at or near the existing Crystal River site was considered among other potential sites within Florida Power's powershed under the following criteria:

1. Adequate supplies of cooling water,
2. Nearness of fuel transportation routes,
3. Distance to Florida Power's load center and transmission system,
4. Available land resources, and
5. Potential environmental, economic, and social impact.

For a complete summary of alternative sites, see Chapter 8 of this document.

ON-SITE LOCATION CRITERIA

Location criteria for proposed units on the Crystal River site were as follows (Black and Veatch, 1976):

1. The plant location shall be compatible with applicable laws, regulations, and environmental standards.
2. The plant shall be located to be accessible to fuel supply, water supply, and electrical transmission lines.
3. The plant shall be located to take advantage of the existing substations, roads, railroad trackage, cooling water system, and coal-handling facilities.
4. The plant shall be located to provide sufficient area for construction laydown.
5. The plant shall be located so that it does not interfere with the operation of the existing units during plant construction.
6. The plant shall be located and plant facilities arranged such that plant operations will not affect the safety and security of the nuclear plant (Crystal River Unit 3).

LAYOUT CRITERIA

Layout requirements included physical space requirements and arrangements needed for each of the following major plant functional systems (Black and Veatch, 1976):

1. Two 600 Mw (net capacity) coal-fired steam generating units including office, maintenance, warehousing, and personnel facilities.
2. Flue gas emissions control systems including electrostatic precipitators and a separate chimney for each unit. Site planning included provisions for future SO_2 scrubbers.
3. Space allocation for closed cycle cooling systems incorporating round natural draft towers and associated underground piping systems for condenser cooling and cooling tower makeup and blowdown water.
4. Coal delivery and handling systems including facilities for both rail and ocean-barge delivery of coal, and for storing, processing, and conveying coal to the steam-generating units.
5. Electrical transmission system to the existing plant substation complex. Site planning included allocation of space for transformers and for transmission lines to both the existing 500 kv and 230 kv substations.
6. Plant water treatment and storage systems including facilities for pretreatment, demineralization, and storage of plant systems makeup water and underground piping corridors for supply pipelines from an offsite well field.
7. Ash handling systems including facilities for collecting and holding ash prior to transport offsite or to onsite disposal areas.
8. Space for future installation of SO_2 scrubber additive receiving, storage, and preparation systems as well as facilities to collect and prepare the process sludge for disposal.

9. Ash disposal area suitable for disposal of ash and rejects material produced by a four-unit station (two new units and existing Crystal River Units 1 and 2) for the life of the plant.
10. Wastewater systems including facilities for storage and treatment of plant system wastes.
11. Construction areas including materials laydown and subassembly work spaces, shop and personnel buildings, warehousing, and access roads.
12. Railroad trackage from the existing plant entrance track to serve construction areas and the coal train unloading facility.

Note: Criterion #9 not achieved by final site ash disposal alternative. Ash disposal area for Units 4 and 5 limited to 95 acres.

9.2.3 ALTERNATIVES CONSIDERED

SITE ALTERNATIVES

The Crystal River site was favored as the site closest to satisfying the siting criteria with the greatest potential for minimizing impacts (see Chapter 8). Figure 9.2-1 shows the Crystal River site, general property boundaries, and surrounding area.

LOCATION ALTERNATIVES

On the basis of location criteria, three locations on Florida Power Corporation's Crystal River property were selected as feasible (Figure 9.2-2):

Location 1. Location 1 would be located to the north and west of the present ash disposal pond for existing Crystal River Units 1 and 2 (Figure 9.2-2). The generation facilities would be located approximately 600 meters (2,000 feet) northwest of existing Units 1 and 2, and the borrow pit/ash disposal area would be located to the north of the existing transmission lines. Additional coal storage facilities would be located immediately west of the existing coal storage facility.

Concern over coastal wetlands and additional cost analysis lead to the evaluation of three additional variations of location 1. These three variations are as follows:

1. Variation 1a. Relocation of generation facilities about 73 meters (240 feet) east of the initial location 1 in order to move all facilities out of the coastal salt marsh.
2. Variation 1b. Relocation of generation facilities about 400 meters (1,300 feet) northeast of location 1 so that all facilities would be out of the salt marsh and impacts on the coastal wetland forest would be reduced.
3. Variation 1c. Relocation of generation facilities about 850 meters (2,800 feet) northeast of location 1 so that all

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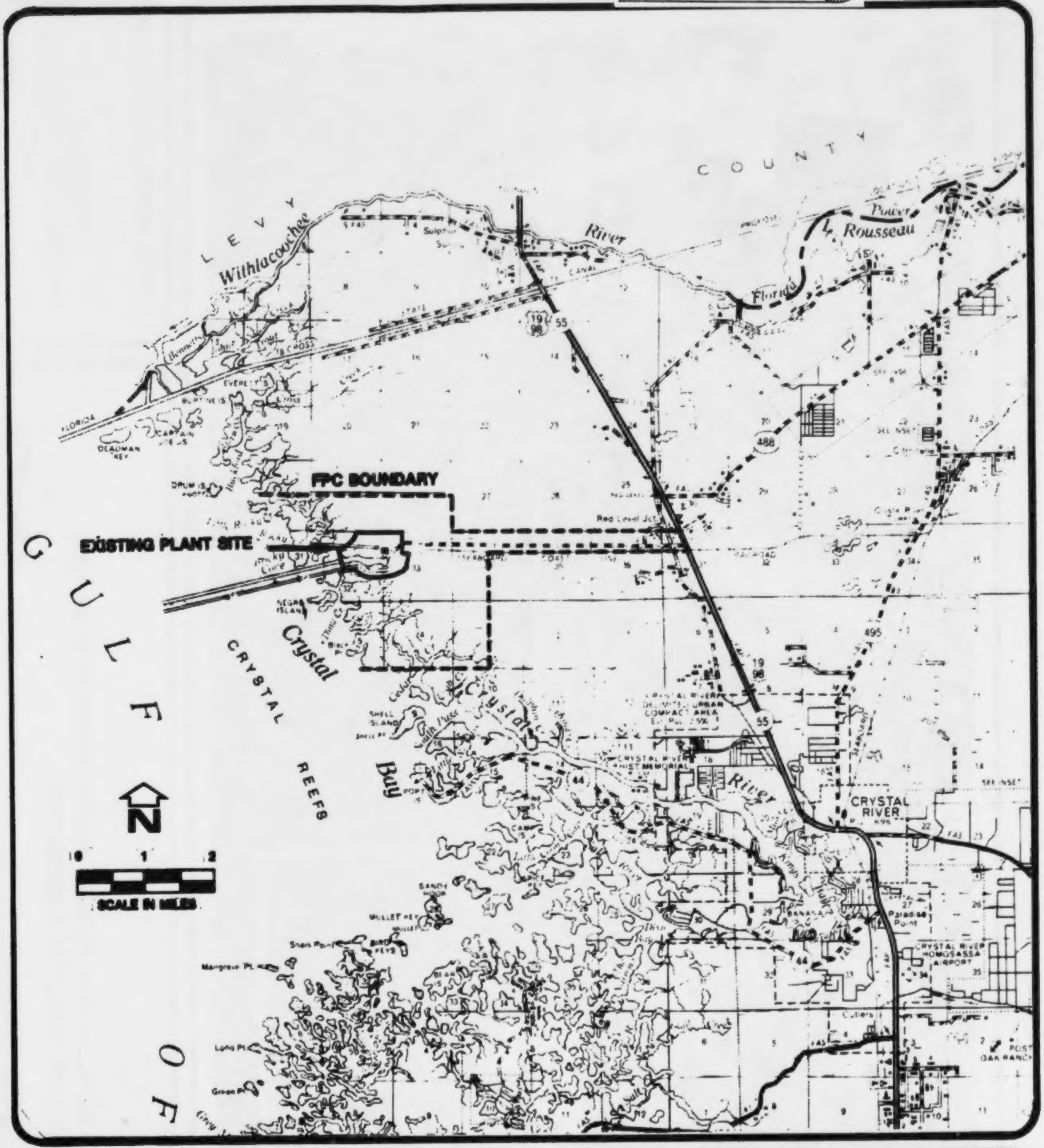

Figure 9.2-1
FLORIDA POWER CORPORATION CRYSTAL RIVER SITE

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1977

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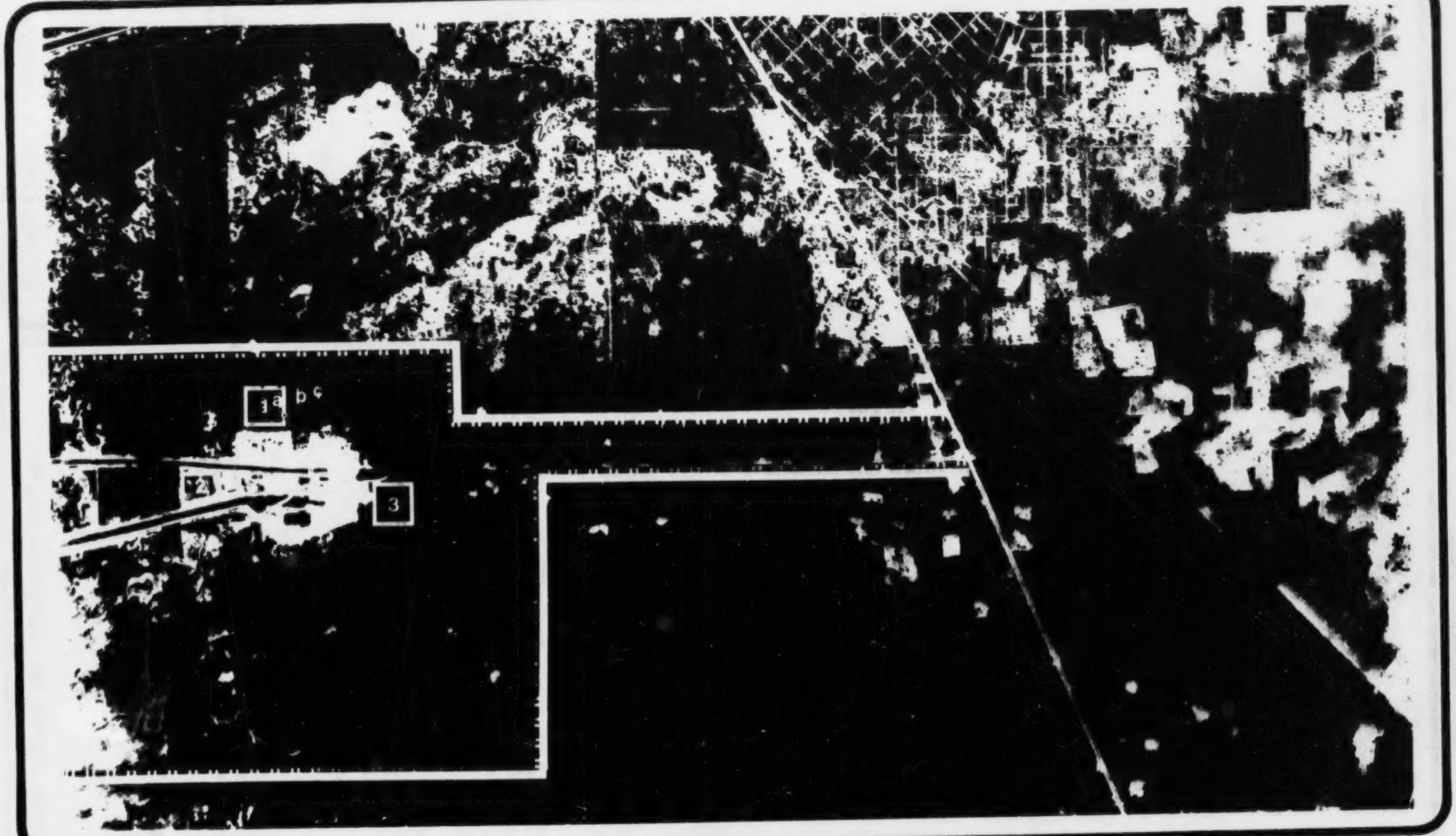

Figure 9.2-2

GENERAL AREA OF PLANT SITE, FLORIDA POWER PROPERTY BOUNDARY, AND PROPOSED PLANT LOCATION ALTERNATIVES

SOURCE: Environmental Science and Engineering, Inc., 1978

FLORIDA POWER CORPORATION

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CITRUS COUNTY, FLORIDA

facilities would be out of the coastal salt marsh and coastal wetland forest.

Location 2. The generation facilities would be located between the existing intake and outfall canals approximately 820 meters (2,700 feet) to the west of Unit 2 (Figure 9.2-2). A portion of the area has been used for experimental mariculture and the remainder is salt marsh. The coal handling and storage facilities would be located identically to the location 1 arrangement, and the ash disposal area would be located in approximately the same location.

Location 3. Generation facilities for location 3 would be located approximately 450 meters (1,500 feet) southeast of existing Crystal River Unit 3 (Figure 9.2-2). Coal handling and storage facilities are identical to those of the location 1 arrangement, but the ash disposal area is located in the southeast portion of the property.

LAYOUT ALTERNATIVES

Details of layout alternatives depend upon final selection of the plant design and auxiliary systems. The following layouts present feasible arrangements of the facility at locations 1, 2, 3, or 1c with three cooling water alternatives. Figures 9.2-3, 9.2-4, 9.2-5, and 9.2-6 depict locations 1, 1c, 2, and 3 with natural draft towers. Possible layouts using mechanical draft towers are presented for locations 1, 2, and 3 in Figures 9.2-7, 9.2-8, and 9.2-9. Figures 9.2-10, 9.2-11, and 9.2-12 present layouts for locations 1, 2, and 3 if once-through cooling is used.

To a large extent the final layout of the plant is determined by decisions on alternatives selected for major plant components like cooling, coal handling, water sources, waste discharges, and air pollution control equipment. In the following section alternative locations and layouts are discussed.

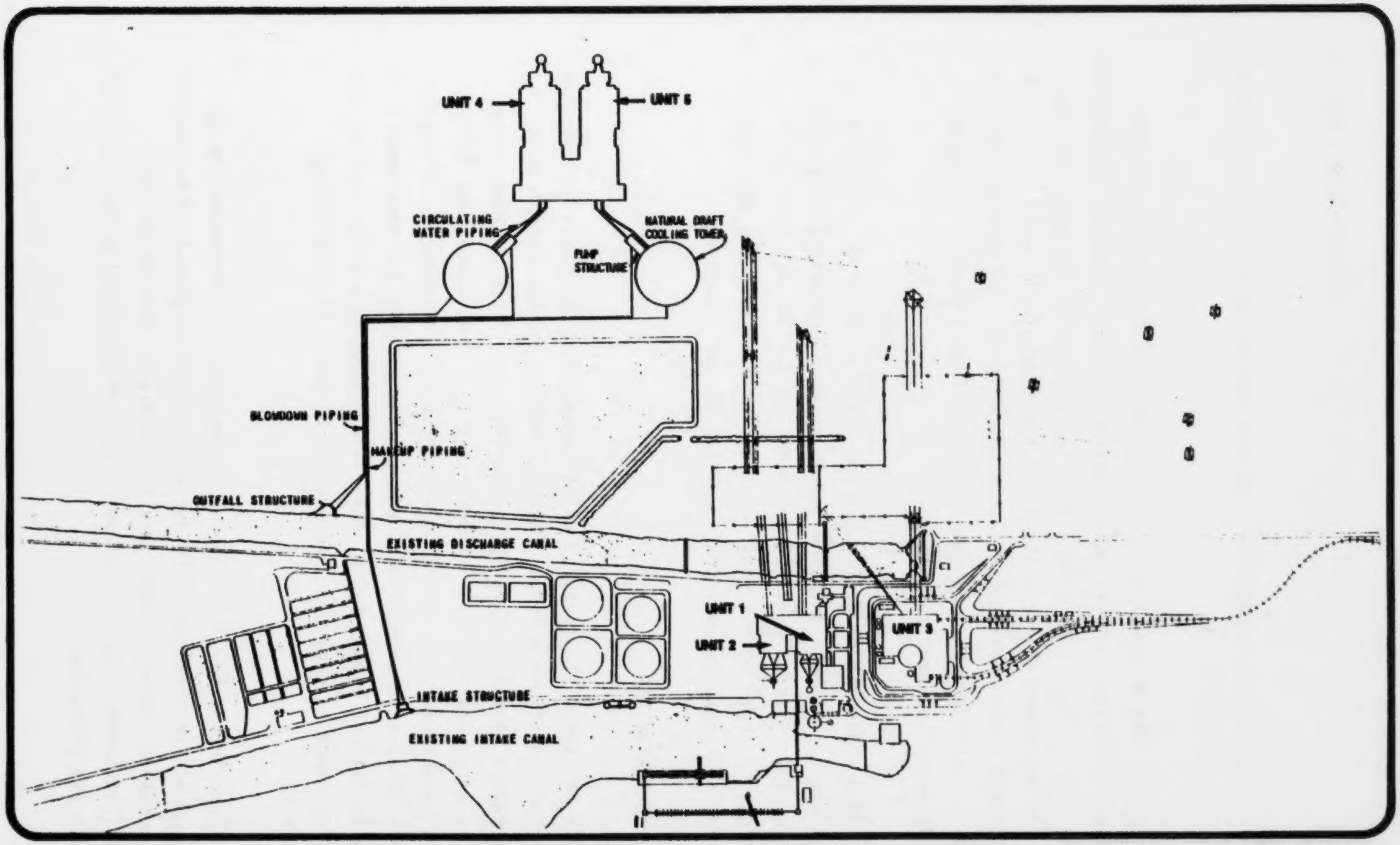

Figure 9.2-3
PROPOSED ALTERNATIVE LOCATION 1 WITH NATURAL DRAFT COOLING TOWERS

SOURCE: BLACK AND VEATCH, 1976

N

0 200 400 800
SCALE IN FEET

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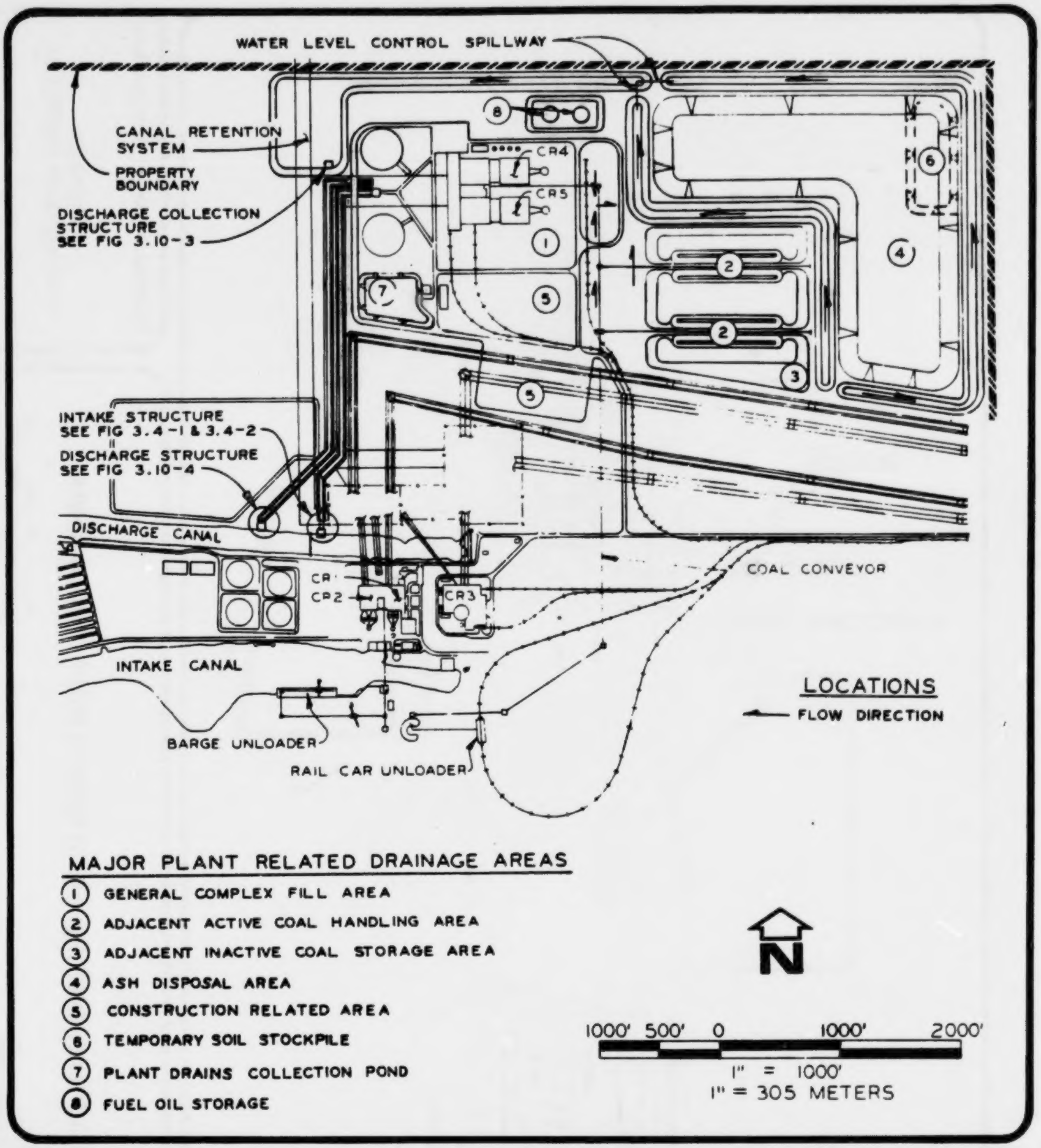
WATER LEVEL CONTROL SPILLWAY
CANAL RETENTION SYSTEM
PROPERTY BOUNDARY
DISCHARGE COLLECTION STRUCTURE SEE FIG 3.10-3
CR4
CR5
8
1
2
2
3
4
5
5
6
7
INTAKE STRUCTURE SEE FIG 3.4-1 & 3.4-2
DISCHARGE STRUCTURE SEE FIG 3.10-4
DISCHARGE CANAL
CR1
CR2
CR3
COAL CONVEYOR
INTAKE CANAL
BARGE UNLOADER
RAIL CAR UNLOADER
LOCATIONS
FLOW DIRECTION
MAJOR PLANT RELATED DRAINAGE AREAS
1 GENERAL COMPLEX FILL AREA
2 ADJACENT ACTIVE COAL HANDLING AREA
3 ADJACENT INACTIVE COAL STORAGE AREA
4 ASH DISPOSAL AREA
5 CONSTRUCTION RELATED AREA
6 TEMPORARY SOIL STOCKPILE
7 PLANT DRAINS COLLECTION POND
8 FUEL OIL STORAGE
N
1000' 500' 0 1000' 2000'
1" = 1000'
1" = 305 METERS

Figure 9.2-4

PROPOSED ALTERNATIVE LAYOUT OF VARIATION 1c WITH NATURAL DRAFT COOLING TOWERS

Black and Veatch, 1980

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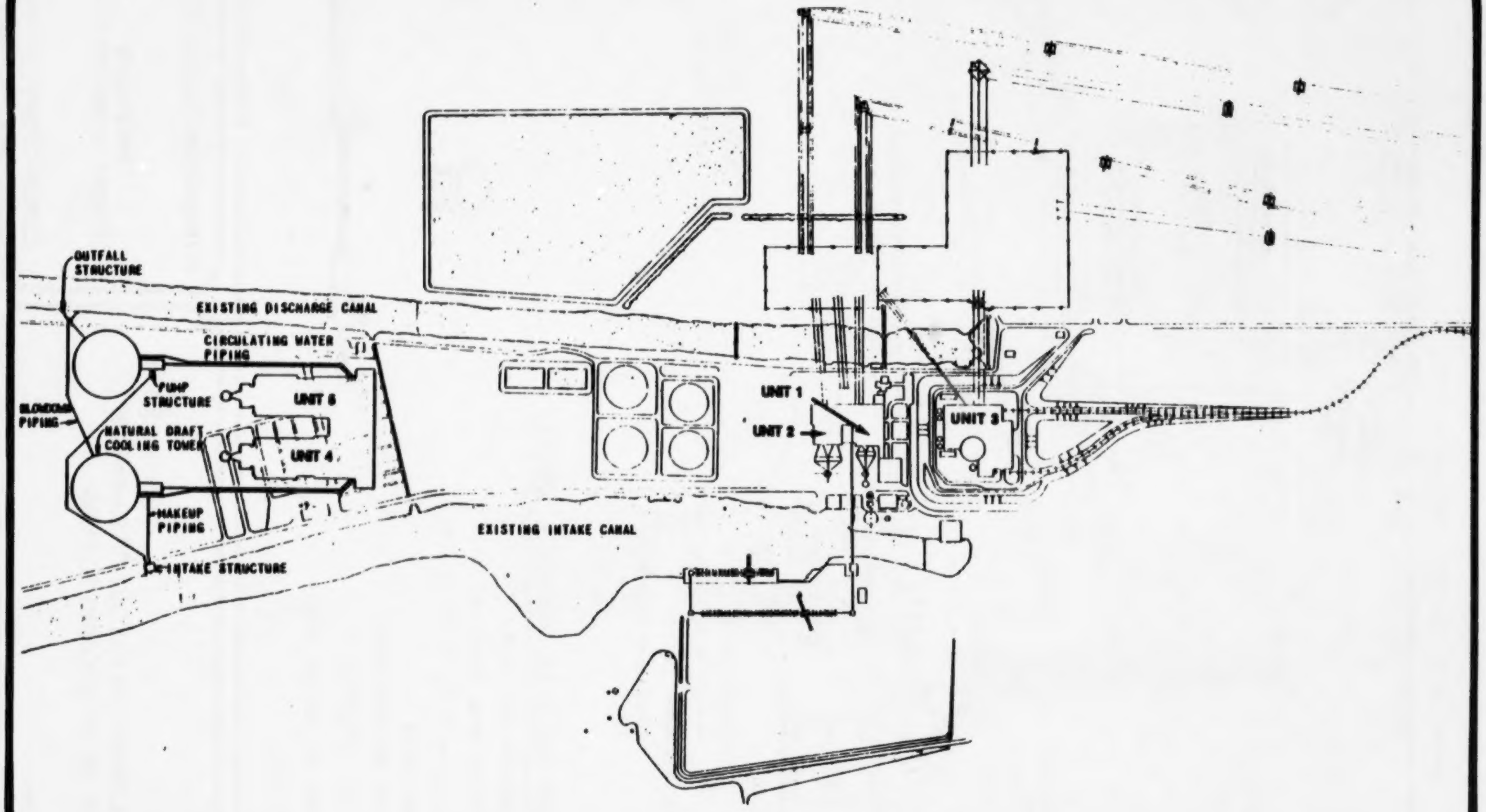

Figure 9.2-5

PROPOSED ALTERNATIVE LOCATION 2 WITH NATURAL DRAFT COOLING TOWER

SOURCE: Black and Veatch, 1976

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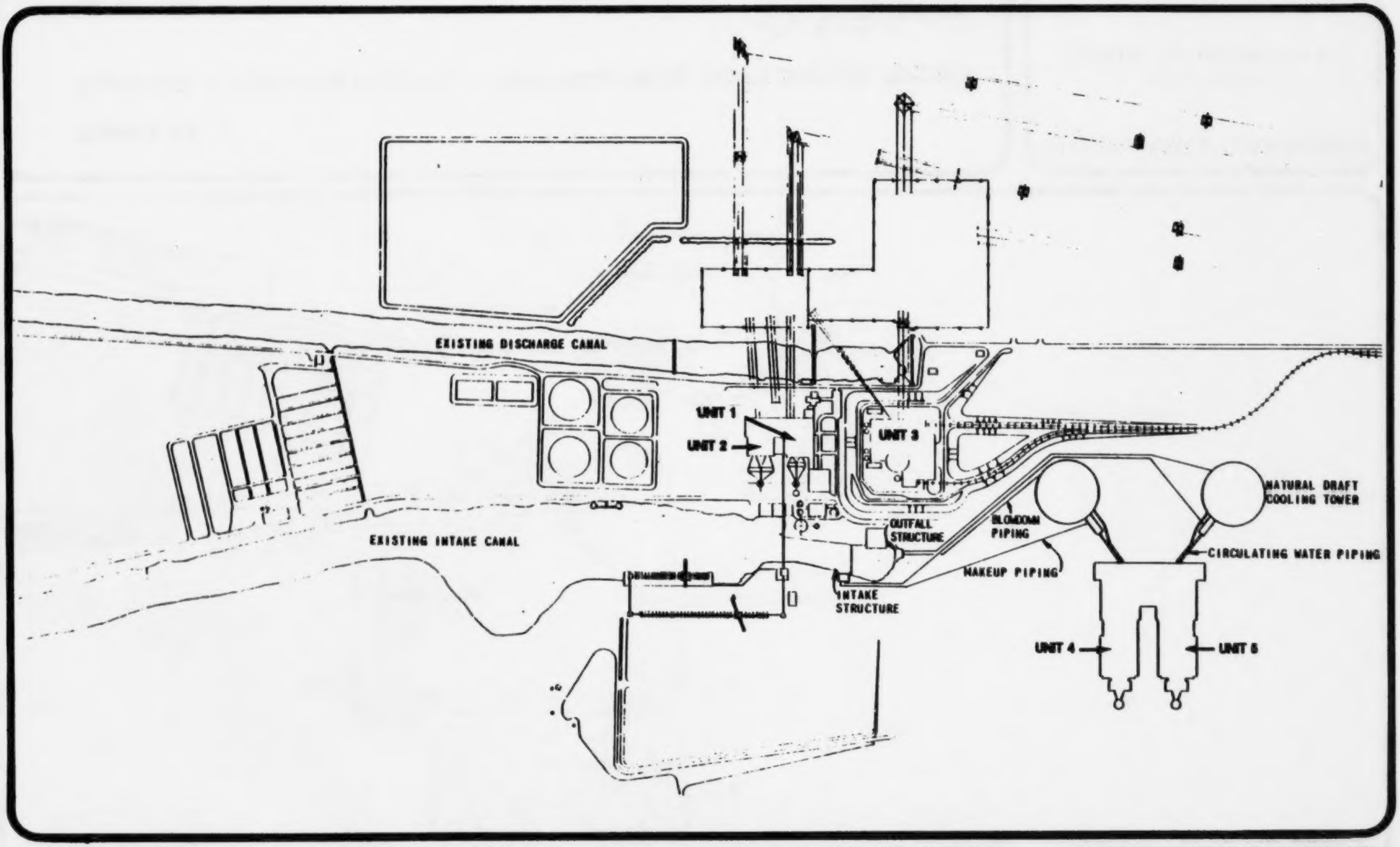

Figure 9.2-6

PROPOSED ALTERNATIVE LOCATION 3 WITH NATURAL DRAFT COOLING TOWERS

SOURCE: Black and Veatch, 1976

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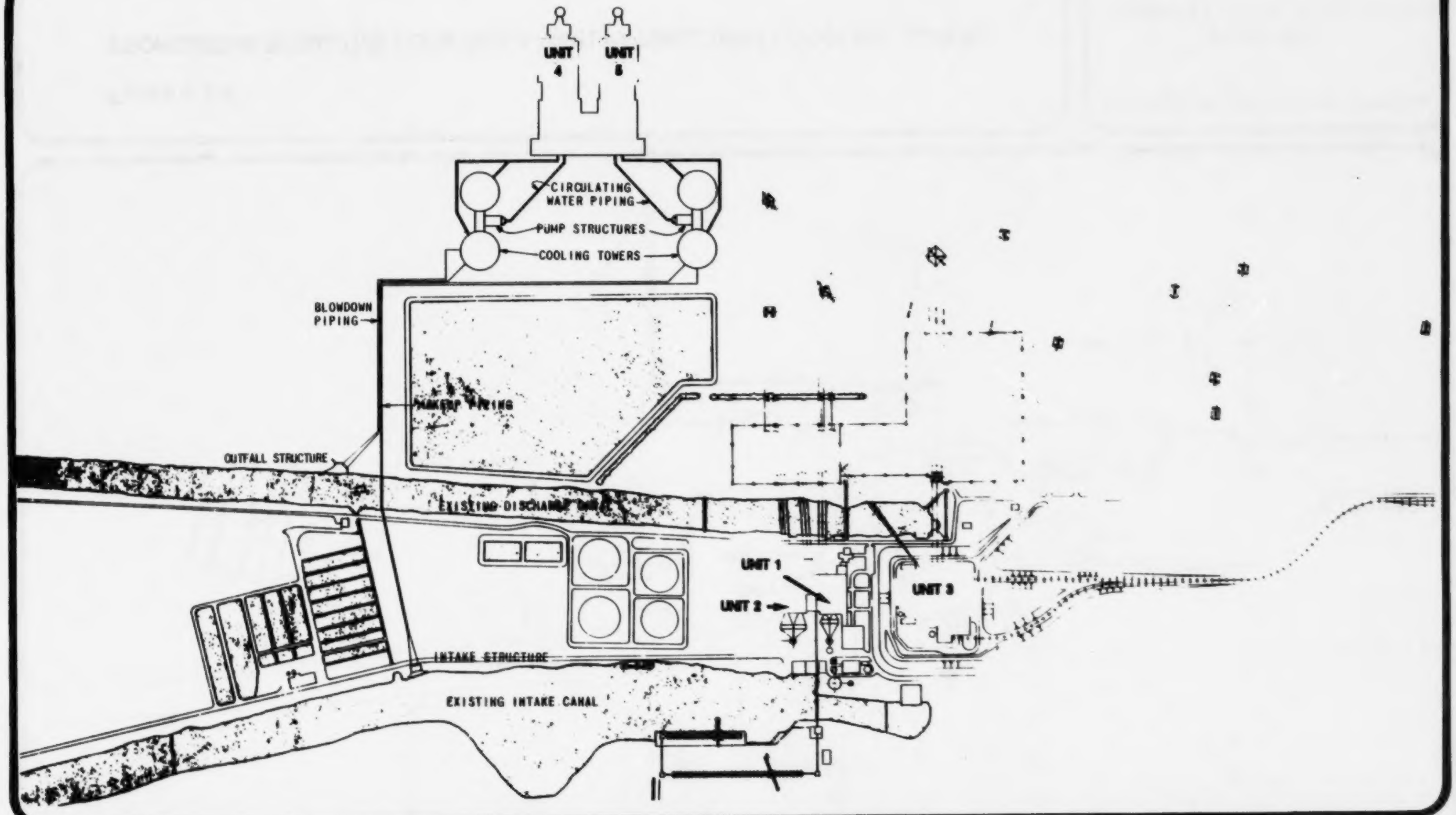

Figure 9.2-7

PROPOSED ALTERNATIVE LOCATION 1 WITH MECHANICAL DRAFT COOLING TOWERS

SOURCE: Black and Veatch, 1976

N

0 200 400 800
SCALE IN FEET

FLORIDA POWER CORPORATION

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CITRUS COUNTY, FLORIDA

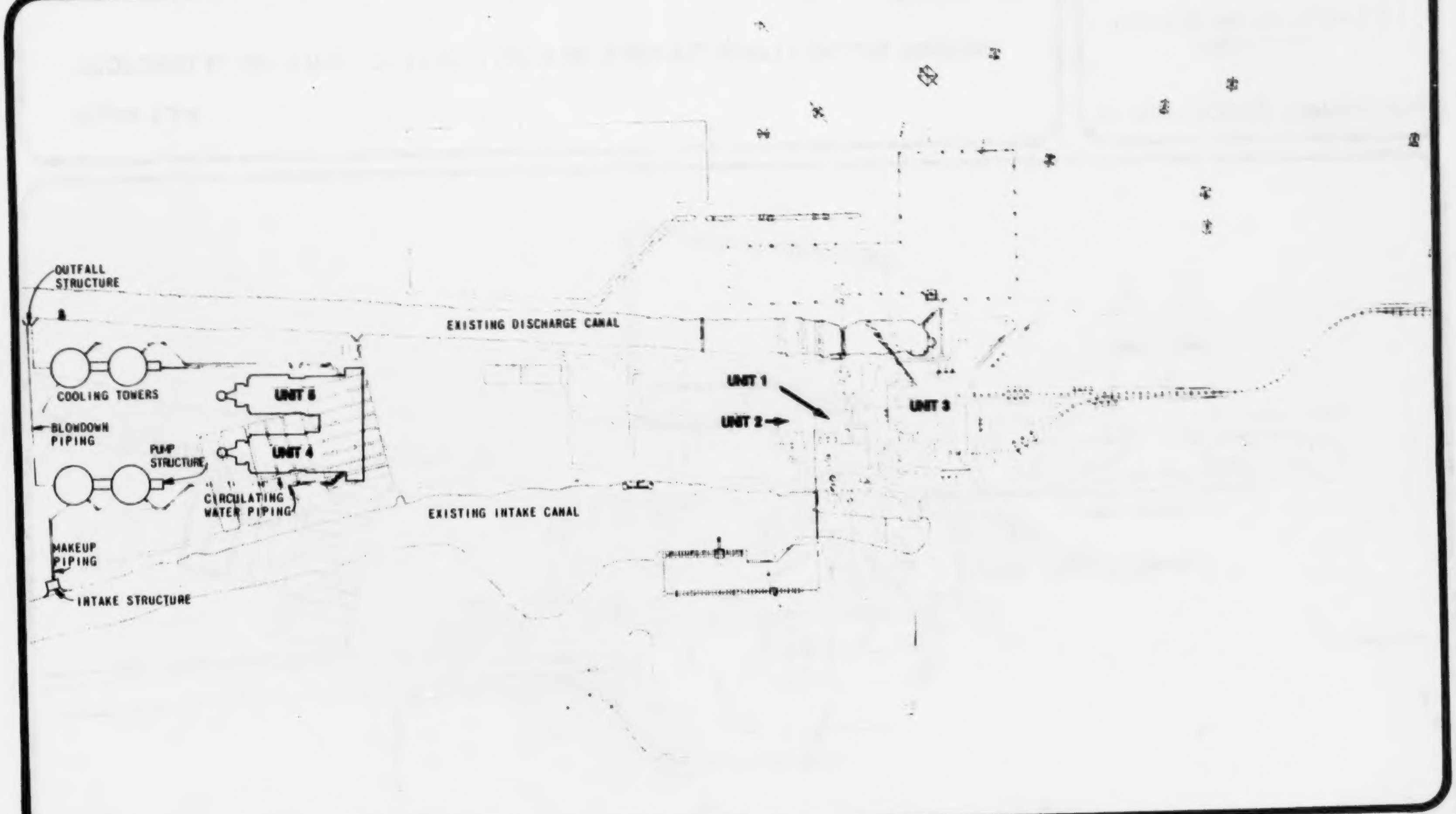

Figure 9.2-8

PROPOSED ALTERNATIVE LOCATION 2 WITH MECHANICAL DRAFT COOLING TOWERS

SOURCE: Black and Veatch, 1976

N

0 200 400 800
SCALE IN FEET

FLORIDA POWER CORPORATION

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CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

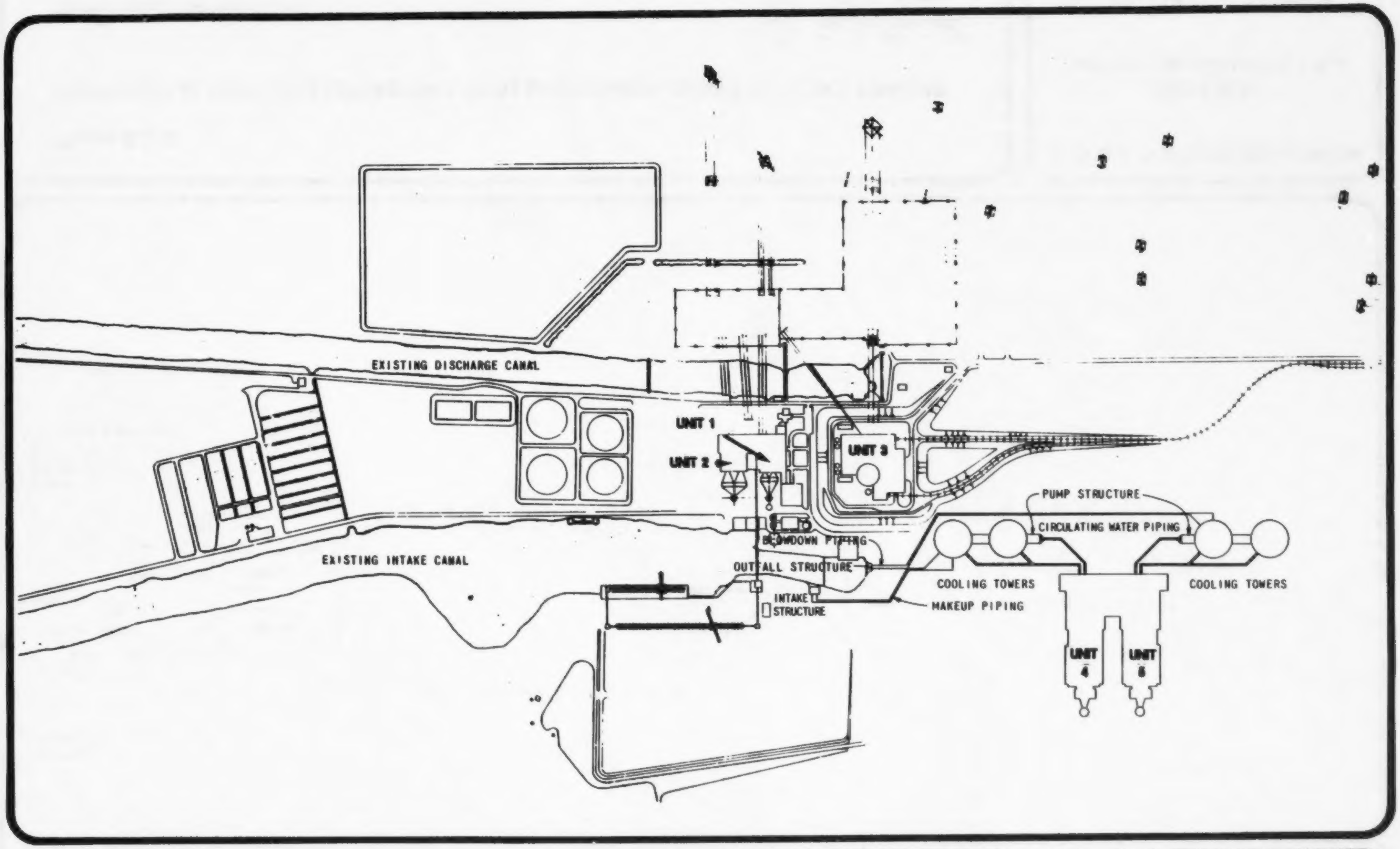

Figure 9.2-9

PROPOSED ALTERNATIVE LOCATION 3 WITH MECHANICAL DRAFT COOLING TOWERS

SOURCE: Black and Veatch, 1978

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CITRUS COUNTY, FLORIDA

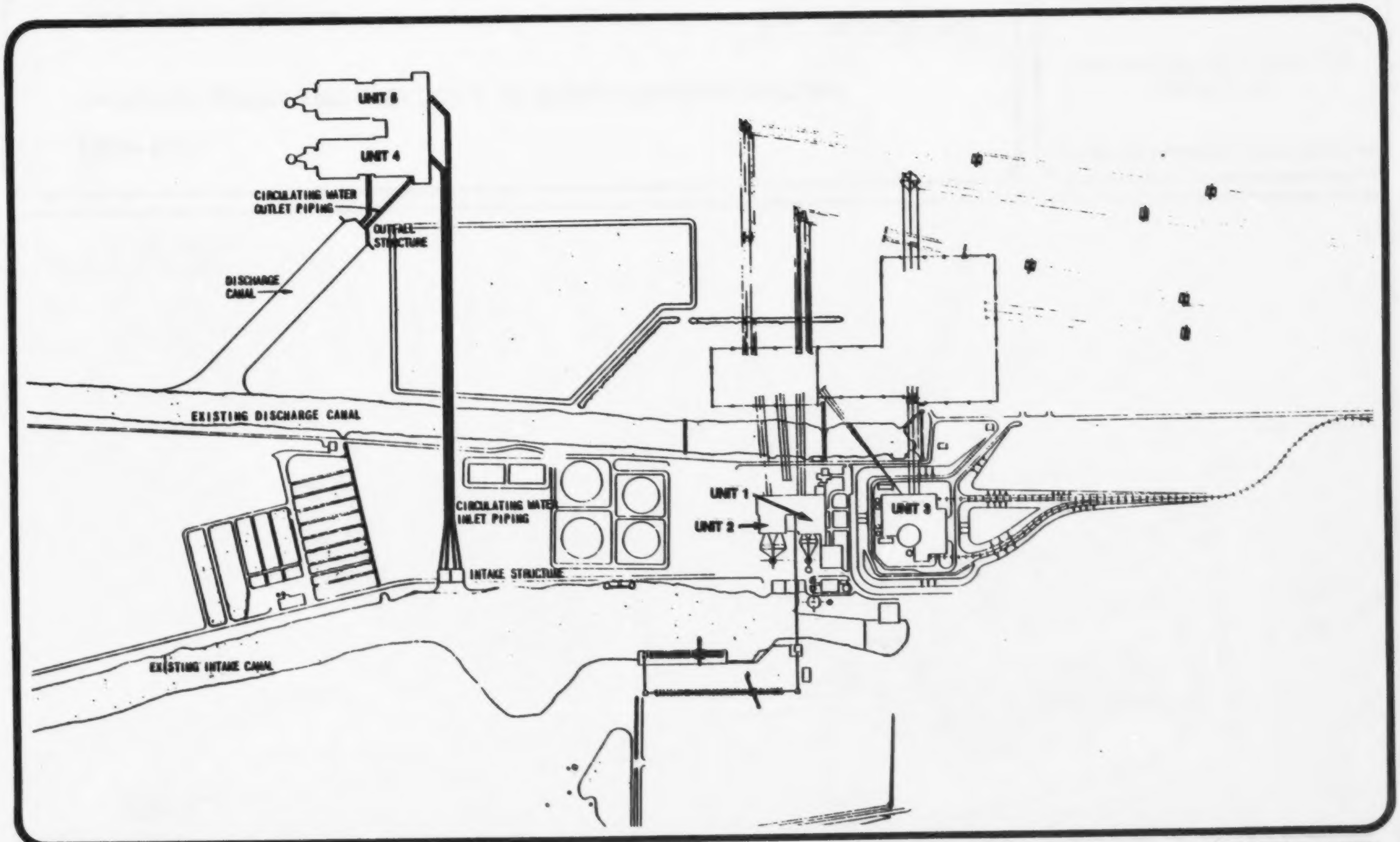

Figure 9.2-10

PROPOSED ALTERNATIVE LOCATION 1 WITH ONCE-THROUGH COOLING

SOURCE: Black and Veatch, 1980

N

0 200 400 800
SCALE IN FEET

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CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

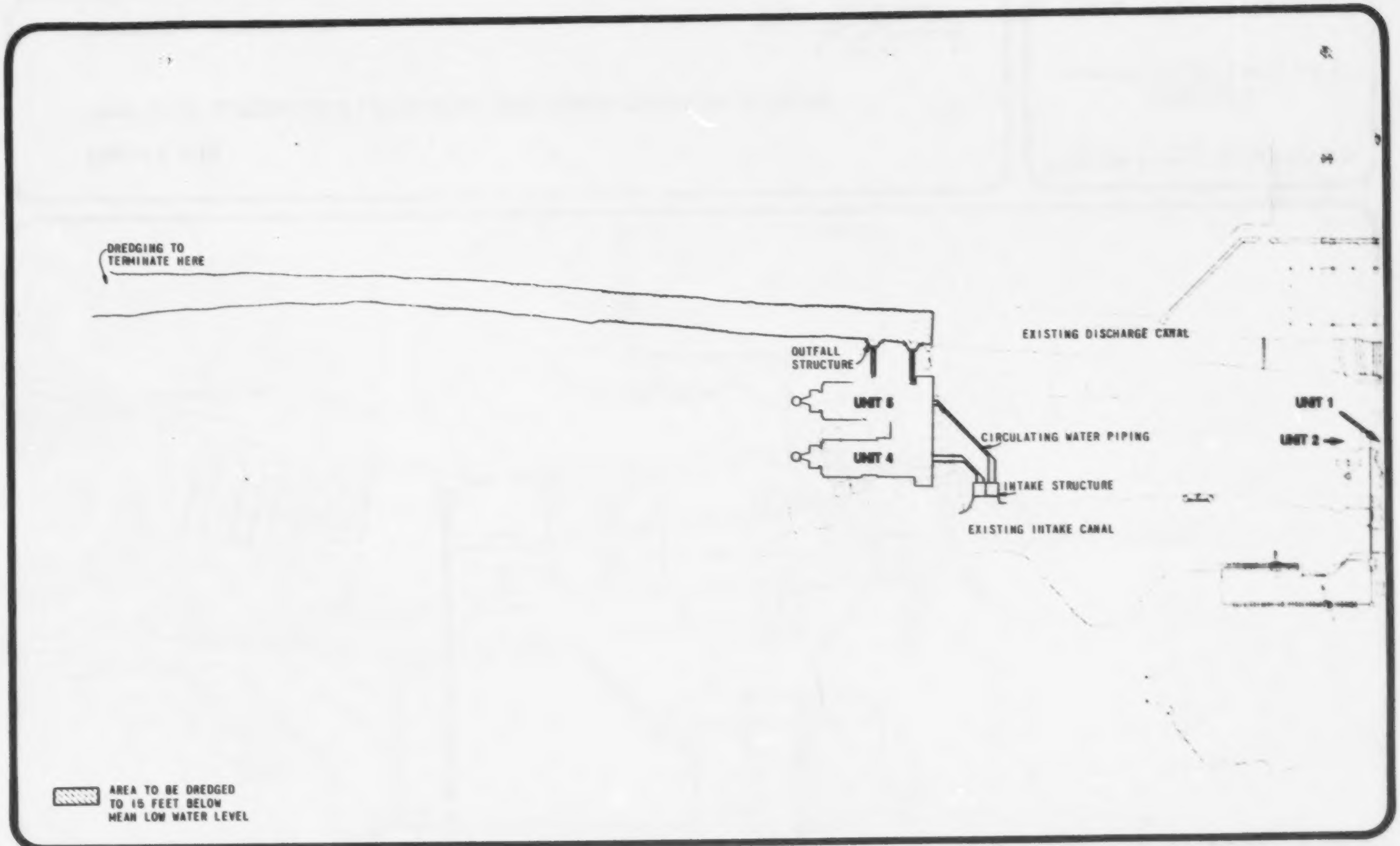

Figure 9.2-11

PROPOSED ALTERNATIVE LOCATION 2 WITH ONCE-THROUGH COOLING

SOURCE: Black and Veatch, 1976

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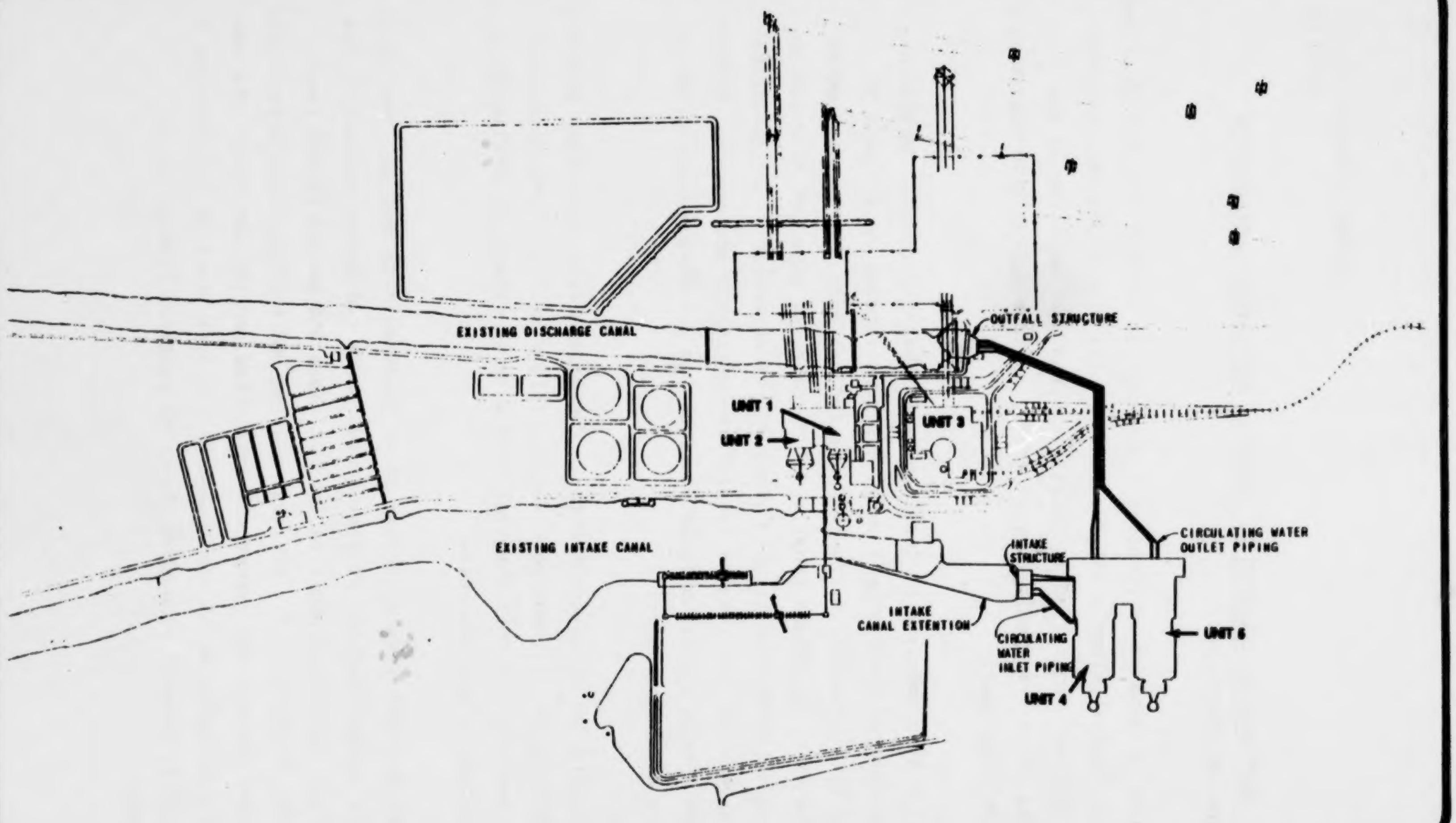

Figure 9.2-12

PROPOSED ALTERNATIVE LOCATION 3 WITH ONCE-THROUGH COOLING

SOURCE: Black and Veatch, 1976

N

0 200 400 800

SCALE IN FEET

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

9.2.4 COMPARATIVE ANALYSIS OF LOCATION AND LAYOUT ALTERNATIVES

LOCATION ALTERNATIVES

The major advantages of location 1 are that it is most isolated from the existing Crystal River plant facilities. The site minimizes interferences with existing plant operations, access, and security of the existing units. Accessibility of roads, railroads, and transmission tie lines is also good.

The major disadvantages of location 1 are that the general facilities, cooling towers, plant runoff pond, and construction areas would be located within coastal marsh and forested wetlands. Using salt water from the existing intake canal would require the pipeline to cross the existing discharge canal, presenting increased exposure for accidental line rupture and may require specialized operating procedures. However, location 1 or a variation could successfully use makeup water from the existing discharge canal.

The installation of tower structures for transmission tie lines within the existing ash disposal pond would create a need for pond management and reclamation, if this disposal area were to remain in service after construction of the new units.

Location 1c represents a relocation of location 1 so that all facilities would be located outside of the coastal marsh and forest wetlands. The generation facilities would be located about 850 meters (2,800 feet) northeast of location 1. New coal storage and handling facilities would be located between the generation facilities and the ash area. The ash storage area would be in approximately the same place as for location 1, but would be reduced from about 81 to 43 hectares (200 acres to 105 acres).

As the generation facilities of location 1 and alternative plans are moved east from the wetlands, a consequent reduction in available space occurs. The advantages of this location include the fact that no coastal marshes or coastal wetland forests will be displaced, and all facilities will be located as far away as possible on the property from the coastal wetlands. Transmission tie line, railroad, and road routings will be minimized. Interference with operation and security of all existing units will be minimized during construction and operations. Access and suitability for construction are excellent.

The major disadvantages of this location include the fact that it does not meet the space requirements for the ash storage area. Thus, a second ash storage offsite will be needed in the future to contain the ash generated by the facility if the planned sale of ash does not materialize. Because the site fabrication and storage-laydown yard areas available for construction are limited, the west end of the ash storage area will have to be used as a construction storage-laydown area. Two separate coal handling and storage areas will be required, thus increasing handling costs and personnel required. Space for the plant and coal runoff canal retention system is limited.

The advantages of location 2 are the short routing distances that are required for makeup discharge pipelines, coal handling conveyors, and transmission tie lines to the existing substations. There would be less displacement of natural vegetation and communities than for locations 1 or 3.

The major disadvantage of location 2 would be that the between-canals location makes access to the plant difficult. All construction materials must cross over the discharge canal from the storage and work areas, with resultant potential for scheduling problems and inefficiency.

Future operations would be adversely impacted because of restricted access, increased distance to ash and sludge disposal areas, and more complicated ash-sludge handling and materials delivery operation. Plant security would be more complex because of the canals splitting the site into three units.

Movement of materials over the discharge canal would increase the potential for accidental release of contaminating substances into the canal.

One advantage of location 3 is the fact that access to this location is excellent. Interference with access and operations of the existing coal-fired units is minimized. The facility is in proximity to the coal storage and ash disposal areas.

The disadvantages of this location include the displacement of extensive amounts of coastal marsh and wetland forest. Transmission tie lines that cross coal-handling yards to the 230 kv substation present potential safety hazards and interference with plant operations. Construction activity would create some disruptions in operation and security of the existing nuclear plant.

Environmental considerations dictate that location 1c be the preferred site. It is the only location which is mainly outside of the coastal wetland areas (Saltwater Marsh and Coastal Hydric Hammock forest--see Vegetation Map, Section 2.7). Secondary effects upon the estuary due to increased runoff and erosion, loss of biological filtration, and accidental spillage are reduced. This location permits retention of the buffer strip or barrier afforded by the coastal forest, thus retaining its value as a hurricane surge buffer and an aesthetic visual screen. Possibilities of water quality impacts due to accidental spillage and dredge and fill activities would be highest for locations 1 and 2, and lowest for location 1c. Location 1c is underlain by some "non-coastal" wetlands, but these are considered to be of less regional importance than the coastal wetlands.

Locations 1, 2, and 3 all cause significant displacement of coastal wetlands. Each of these sites also has a higher potential for release of contaminants and pollutants into the estuarine system. Runoff potential is higher due to proximity to the shore and removal of the coastal wetland forest buffer zone. Location 2 has a potential for accidental spillage of materials into the discharge canal during movement across the canal. Location 1 adversely affects aesthetic appeal because of its high visibility from the Gulf of Mexico.

Location of the ash storage area location north of the access road would lessen the potential of a seepage of pollutants to the estuary because of the greater distance involved. Splitting of the coal storage facilities may increase the difficulty of controlling seepage and runoff problems. However, a smaller area of coastal wetlands would be displaced.

Displacement of a natural system through relocation of railroad spurs and access roads would be minor, although the recommended new access road would affect the narrow visual barrier to the north of the existing transmission lines. It would also cross some small swamp and marsh systems.

LAYOUT ALTERNATIVES

Layout alternatives have not been detailed for all categories of facilities design at this time. Layout design depends on final selection of the auxiliary input and output alternatives such as cooling system and water source.

Coal Handling and Storage Facilities

For location 1, supply would be from the east, with the active storage and stacker-reclaimer about 240 meters (800 feet) east of Unit 5. This alternative was recommended because of lower capital costs and increased active storage area. The space available for ash and sludge storage is reduced, however. An alternative supply would be from the east with active storage, stacker-reclaimer, and inactive storage area all located within the coal yard railroad track loop south of the existing access road.

With the supply from the west, all facilities would remain near the existing coal facilities, with coal conveyed to the west side of the plant around the existing facilities. Increased costs and interference with existing units are disadvantages.

Access Roads

The existing access road could be upgraded and used for both construction and operations traffic. The advantages are the maximum use of existing facilities and minimum of environmental disturbance. The disadvantages are interference with operation and access to existing facilities. A separate access road for Units 4 and 5 would be constructed along the property boundary to the north of the existing transmission lines. While this alternative would result in less interference with the existing units, there would be increased impacts from construction.

Railroad Intersections

Plan A

Elevate U.S. Highway 19-98 to cross over the rail spur to the plants. The existing access road would be simultaneously upgraded for divided access to the highway. Estimated direct capital costs would be $1,385,000. Highway vehicular traffic would be disrupted during construction, but rail traffic would be largely unhindered. This plan may be linked to the access road alternative of upgrading the existing access road.

Plan B

Elevate the plant rail spur to cross Highway 19, and move existing road intersection 91 meters (300 feet) north of its existing location. Direct capital costs are estimated at $1,175,000. Plan B offers less disruption to vehicular traffic, but more for rail traffic.

Plan C

Leave the intersection of U.S. 19-98 and the rail spur at grade and employ unit trains (special trains that are dedicated to Florida Power Coal delivery). With this alternative, trains would take approximately two minutes per direction to cross U.S. 19-98. Four one-way trips per day would be scheduled. (Discussion of railroads is finalized in this subsection.)

Ash and Sludge Storage Areas

Currently, only a 43-hectare (105-acre) storage area east of the plants is proposed. Additional alternative sites to contain the majority of the potential ash and sludge generated have not been identified at this time. Since there is probably insufficient upland area remaining on the property, additional sites presumably would be located in upland areas outside of the property.

Retention and Percolation Basins

At the time of this analysis, specific locations for percolation and retention basins have not been described. They will be located generally to the south and west of the new units.

SUMMARY

Location

Tables 9.2-1 and 9.2-2 summarize advantages and disadvantages of alternative on-site locations.

Alternatives Overview

Figure 9.2-13 is a summary diagram of feasible alternatives for plant siting, location, and layout considered in this section.

Table 9.2-1 Alternative On-Site Locations Summary Matrix

Location	Costs (1,000's)	Location and Development		Environment	
		Advantages	Disadvantages	Advantages	Disadvantages
1	424,635	1. Near to ash disposal area. 2. Isolated from neighbor lands. 3. Room for four-unit expansion. 4. Second nuclear unit possible.	1. Transmission tie towers in existing ash pond—pond management problems. 2. Adjacent to neighboring lands.		1. Location in coastal wetlands. 2. Higher runoff potential. 3. Elimination of storm buffer zone. 4. Aesthetic impact on Gulf side.
1C	422,427	1. Minimal routing for roads, transmission tie lines, and railroad. 2. Excellent constructability.	1. Proximity to neighboring lands. 2. Not enough ash storage space. 3. Reduced space for retention ponds. 4. Limited construction laydown area.	1. No disruption of coastal wetlands. 2. Least total wetlands disruption. 3. Retains visual buffer to Gulf. 4. Retains storm buffer zone.	1. Additional ash storage displaced from site. Impacts may occur at another site.
2	427,575	1. Short routing for makeup discharge pipe, coal conveyors, and transmission tie lines. 2. Isolated from neighbor lands.	1. Construction materials must cross discharge canal—delays and accidents.	1. Reduced displacement of natural systems.	1. Ash pond located in coastal wetlands. 2. High runoff potential. 3. Potential accidental release of contaminants to discharge canal.
3	420,490	1. Proximity to coal and ash disposal areas. 2. Isolated from neighbor lands.	1. Precludes second nuclear unit.		1. Location in coastal wetlands. 2. Aesthetic impact on Gulf side. 3. Runoff potential.

Source: Environmental Science and Engineering, Inc., 1978.

Table 9.2-2. Alternative Locations Summary Matrix

Location	Costs (1,000's)	Access and Interference		Security and Safety	
		Advantages	Disadvantages	Advantages	Disadvantages
1	424,635	1. Most distant from existing plants. 2. Minimal interference to existing plants. 3. Excellent access to roads, railroad, transmission tie lines, and discharge canal.		1. Will not be potential fire/explosion hazard to nuclear unit. 2. Allows rapid employee exit from property. 3. Will not disrupt security of existing units.	
1C	422,427	1. Minimal interference with existing units. 2. Excellent access.		1. Minimal interference with existing security. 2. Excellent employee exit.	
2	427,575		1. Access during construction difficult. 2. Access for delivery of operational materials difficult.		1. Increased difficulty of security on three-part site. 2. Poor employee exit from property.
3	420,490	1. Excellent access. 2. Minimal operational interference with existing units.	1. Some interference with existing units during construction.		1. Transmission tie lines must cross coal handling facility. 2. Disruption of CR3 security during construction.

Source: Environmental Science and Engineering, Inc., 1978.

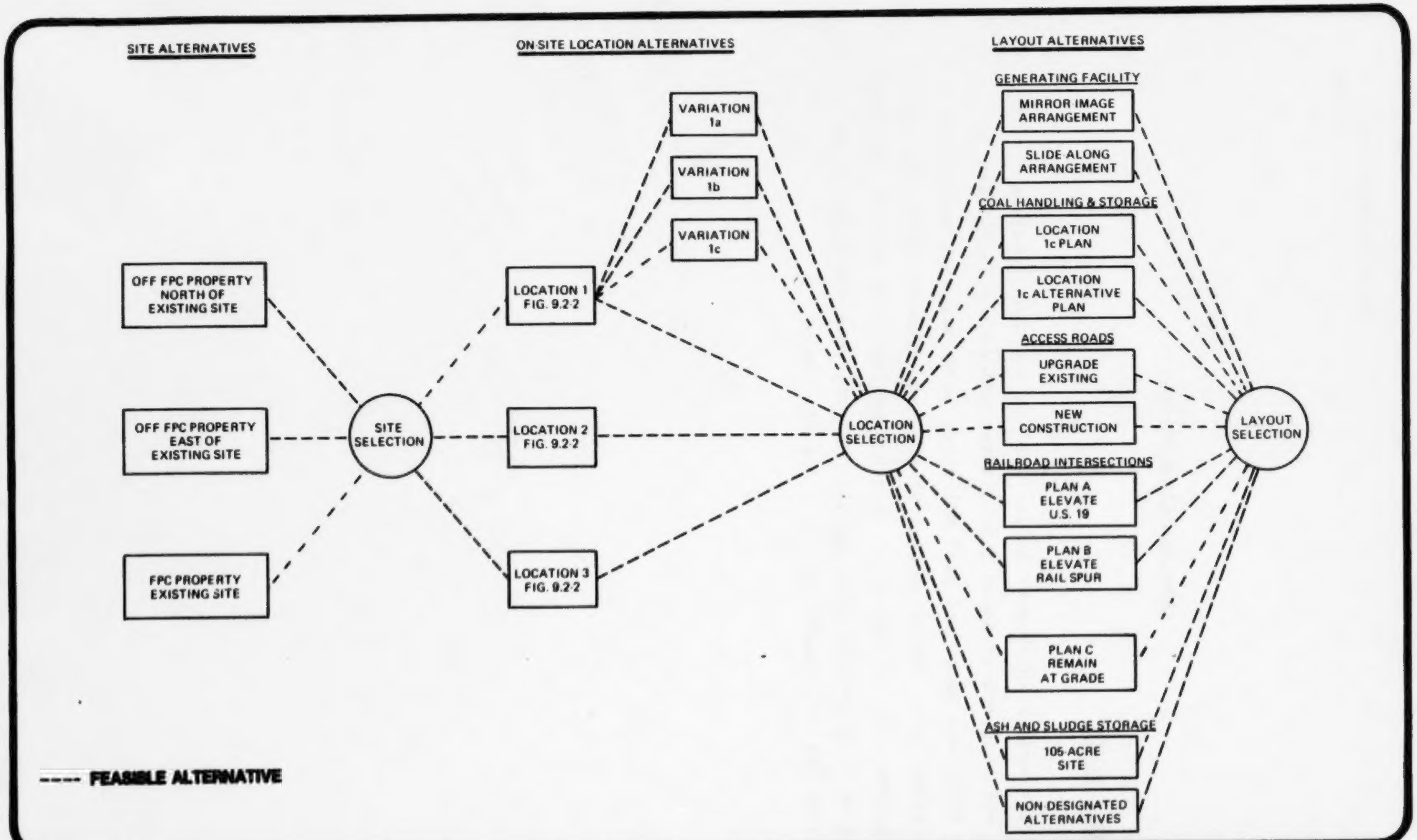

Figure 9.2-13

FEASIBLE ALTERNATIVES—PLANT SITING, LOCATION AND LAYOUT SUMMARY DIAGRAM

SOURCE: Environmental Science and Engineering, Inc., 1978

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9.3 COAL HANDLING SYSTEMS

9.3.1 OBJECTIVES

The major elements which must be included in any coal handling system for the existing and proposed fossil steam generating facilities at Crystal River are barge and rail delivery, barge and rail unloading, primary stock out, reserve and active storage, crusher system and plant supply system. The objective of this subsection is to provide an understanding of proposed and existing alternatives considered for major elements of the coal handling system outlined above.

9.3.2 EVALUATION CRITERIA

The following criteria were used as a basis for developing coal handling alternatives:

1. Site arrangement should be designed to accommodate a broad range of both high- and low-sulfur content coals from mine source areas in the eastern and western United States.
2. Combined facility for serving two existing and two proposed coal-fired plants should be designed to handle 6,536,160 metric tons (7,203,115 tons) per year, with a reserve of 1,634,040 metric tons (1,800,780 tons).
3. Reception facilities should be able to handle deliveries of 571,900 to 599,200 metric tons (630,260 to 660,340 tons) per month.
4. Coal terminal facilities should be designed for deliveries by unit trains, oceangoing barges, or both trains and barges.
5. Coal supplies intended for the existing power generation units must necessarily be segregated from supplies for the new units (consisting of low-sulfur coal). Allowing for this factor and for mobile equipment access, the total land requirements for reserve storage would amount to about 15 hectares (37 acres).
6. The volume of active storage should equal a 3-day supply of coal for both the new and existing units. Separate storage and reclaim facilities for the two sets of units would be appropriate. For operation at 90 percent of capacity, utilizing the worst coals, the 3-day fuel requirements would be about 24,500 metric tons (27,000 tons) for the existing units and 49,000 metric tons (54,000 tons) for the new units.
7. The procedure utilized in developing and evaluating alternatives has been to assume that both the barge unloading facilities and the rail facilities should be sufficient to meet the full needs of the plant. Given this assumption, the effective production rating of both the barge terminal and the rail terminal should be on the order of 1,360 metric tons (1,500 tons)

per hour; and the capacity of conveyor systems, feeders, reclaimers, etc., should be 2,700 to 3,200 metric tons (3,000 to 3,500 tons) per hour.

8. The coal handling arrangements should involve an integrated system with the ability to stock-out from either unit train or barge unloading facilities to the active storage area or segregated reserve storage area serving each pair of units.
9. Coal storage areas should if possible be located away from coastal marsh and coastal wetland forest areas.

SITING OF COAL HANDLING FACILITIES

The selection and siting of coal handling facilities must obviously be coordinated with the siting of the power generating units and related facilities such as ash storage ponds. Table 9.3-1 summarizes the key characteristics of eleven alternative coal handling plans which have been considered in the design process. Each plan involves one of the four plant sites (see Section 9.2), one of the rail unloading options, and a specific arrangement of rail lines and coal storage areas. The last four columns describe the locations of the major land-extensive facilities relative to the existing reserve storage area (which is just south of the existing active storage area and barge unloading dock).

Table 9.3-1 Characteristics of Alternative Coal Handling Plans

	Type of Coal Unloading Facility	Type of Rail Access	Location of Facilities Relative to Existing Reserve Storage Area			
			Unloading Facility	Rail Lines	New Active Storage	New Reserve Storage
Plans Serving Locations 1 or 2						
I	Trestle Dump	Loop	South	South, Southwest	South	South
II	"Rotoside" Rotary Dumper	Ladder	South	South, Southwest	South	South and East
III	Trestle Dump	Loop	East	East, Southeast	South	South and East
IV	Conventional Rotary Dumper or Bottom Dump Hopper	Loop	South	South, Southwest	West	West
VII	Bottom Dump	Loop	East	East	West	West
IX	Bottom Dump	Loop	East	East	South	Southeast

Table 9.3-1 Characteristics of Alternative Coal Handling Plans (Continued, page 2 of 2)

	Type of Coal Unloading Facility	Type of Rail Access	Location of Facilities Relative to Existing Reserve Storage Area			
			Unloading Facility	Rail Lines	New Active Storage	New Reserve Storage
Plans Serving Location 3						
V	Trestle Dump	Loop	South	South, Southwest	Southeast	South
VI	"Rotoside" Rotary Dumper	Ladder	South	South, Southwest	South	South and East
VIII	Bottom Dump Hopper	Loop	South	South, Southwest	South	South and East
Plans Serving Location Variation 1c						
X	Bottom Dump Hopper	Loop	East	East	South or East	East
XI	Bottom Dump Hopper	Loop	East	East	Northeast	East

Source: Black and Veatch, 1976.

9.3.3 ALTERNATIVES CONSIDERED

Coal is unloaded from barges and/or unit trains and is either delivered directly to the generating units or stocked out to active storage or reserve storage. Active storage is required to provide for short-term variations between coal usage and supply, particularly during periods when car or barge unloading and yard operations might be curtailed. Long-term storage is needed to level variations between coal purchase contractual commitments and station usage. The primary stockout and reclaim systems, serving active storage, must be designated so that coal is available for automatic reclaiming without resorting to coal dozers or other mobile reclaim equipment. The emergency stockout system, serving reserve storage, will allow barge or train deliveries to continue in the event that the primary stockout systems are unavailable. Other major coal handling facilities are the emergency reclaim hoppers, the crusher system, the coal sample system, and the interconnected network of conveyors, surge bins, and feeders.

The requirement for new coal handling facilities were considered in light of existing and contracted facilities for serving Units 1 and 2, requirements for proposed units, and siting of the overall facility.

The location of facilities is critical since nearly all the land to the west and south of the existing reserve storage area is presently either coastal marsh or coastal wetland forest. Encroachment upon these areas would constitute a serious environmental impact, as discussed elsewhere. Table 9.3-1 serves to indicate that it is rather difficult to provide adequate coal storage and rail access at the Crystal River site without utilizing wetland areas. However, the alternative ultimately selected does accomplish this objective.

Many of the alternatives listed in Table 9.3-1 were ruled out when the fuel subsidiary company decided to proceed with construction of a rail loop and bottom dump unloading facility east of the present reserve storage area. Only Plans VII thorugh XI remained viable, barring major alteration or replacement of the facilities now under construction. Next, the overall site evaluation process described earlier yielded the conclusion that location 1c would be the best location for the new power generating units.

The remaining choice was between coal handling Plans X and XI, which differed only with regard to the location of the active storage area for the new units. It was found that insufficient land was available for this facility near the rail unloading area, if adequate reserve storage was to be provided without encroaching significantly upon wetlands. Therefore, the new active storage area has been sited north of the access road and transmission corridor, near the new generating units, even though this has cut into the land available for ash storage and construction laydown. It is apparent from Table 9.3-1 that this chosen alternative (Plan XI) is preferable to all other alternatives in terms of ecosystem protection.

EXISTING AND COMMITTED FACILITIES

Coal supplies for Crystal River Units 1 and 2 have in the past been received by barge. The existing facilities are designed for the unloading of oceangoing barges with net capacities of up to 13,600 metric tons (15,000 tons) and loaded drafts of up to 4.3 meters (14 feet). There is a barge and tug mooring dock, a clamshell type barge unloader, a stacker-reclaimer, and a belt conveyor system connecting the barge unloader and stacker-reclaimer. The rated capacity of the unloading and stockout systems is 1,360 metric tons (1,500 tons) per hour, and the capacity of the reclaiming and coal preparation systems is 540 metric tons (600 tons) per hour. Active storage for the existing units is located adjacent to the barge dock, and a reserve storage area of roughly 6.5 hectares (16 acres) is located further south.

The fuels contractor for the plant (Electric Fuels Corporation) has recently contracted for the installation of a railcar unloading facility to serve the existing units, which went into service in 1978. As presently designed, this installation includes the following components:

1. A railroad loop track for coal delivery and unit train turnaround. The track branches to the south from the existing Crystal River Unit 3 plant spur, rises about 9 meters (30 feet) to the unloading point, and then descends to grade at the original turnout point. The unloading loop includes approximately 1,500 meters (4,800 feet) of new track.
2. An elevated structure for bottom dumping of railcars having power operated hopper doors. The dump structure is about 30 meters (100 feet) long and includes multiple hoppers served by a single collecting conveyor.
3. A belt conveyor linking the dump structure with the existing coal handling system at the tailpoint of the barge dock belt.

NEW FACILITIES FOR PROPOSED UNITS

Barge Unloading Facilities

The peak barge unloading capability with the existing clamshell type unloader and associated conveyors is about 15,400 metric tons (17,000 tons) per day under optimum conditions. The unloader is probably adequate for sustained delivery rates to about 295,000 metric tons (325,000 tons) per month without seriously jeopardizing machine design or maintenance procedures. Thus, depending upon the proportions of annual coal requirements to be delivered by barge, the existing facilities may be marginal for the demands of the four coal-fired units. Two alternative methods of upgrading the terminal unloading operations have been proposed.

Plan 1

Add a second barge unloader and extend the existing dock approximately 27 meters (88 feet) to the east to accommodate longer barges, compensate for the decreased travel of the dual machines, and provide space for machine erection while maintaining unloading operations for the existing units. The second machine would be similar in design and unloading capabilities to the existing unloader. The paired machines, operating in separate holds of a barge, would raise the effective production rating of the terminal to an average of about 1,540 metric tons (1,700 tons) per hour.

Plan 2

Replace the existing barge unloader with a high capacity, continuous ladder type barge unloader rated at 2,700 metric tons (3,000 tons) per hour (free digging capacity). The existing dock would be extended approximately 40 meters (132 feet) to the east to provide erection space accommodating the trailing surge-bin and yard conveyor loadout structure required by this type of unloader.

Improvements to the existing unloading facilities under either plan would include the installation of a second conveyor system paralleling the existing conveyor. The discharge point of the new conveyor would be designed to feed either the existing stacker-reclaimer yard belt or a new 2,700-metric ton (3,000-ton) per hour conveyor extending to the active storage and stockout systems provided for the new units. If retained under Plan 1, the existing unloader would be modified somewhat, but still might limit barge unloading operations involving coals dedicated to the existing power generation units. The relative advantages of Plan 1 would involve operation flexibility, redundancy, and the ability to use existing dock trackage without modification. The advantages of the ladder type unloader would include better control of fugitive dust, greater efficiency in free digging and cleanup modes, and more exact maintenance costs.

A cost comparison of the two barge unloading alternatives has indicated that Plan 2 would be higher in terms of capital cost ($8,150,000 versus $4,810,000 for Plan 1) but lower in terms of other annualized costs ($573,000 versus $1,016,000 for Plan 1). The total annualized cost of Plan 2 would be $2,517,000, and the annual cost of Plan 1 would be $2,163,000. Thus, the addition of a second clamshell type barge unloader (Plan 1) is the most economical alternative if increased barge unloading capability is required for future terminal operations.

Other Coal Handling Facilities

The present discussion has focused primarily upon facilities that would constitute major points of difference among alternatives. Some of the other facilities deserving mention are the stacker-reclaimer unit, the crushers, the emergency stockout system, and the conveyors. All of the alternatives have assumed the use of a slewing type stacker-reclaimer at the new active storage area rather than a trench type, due to the need for a longer track and power control system in the latter case to achieve comparable storage capability. The use of silos for active coal storage was determined to be economically unfeasible, although attractive in many respects. A similar decision was made with regard to groundlevel storage with gravity feed to underground conveyors.

A crusher structure with two 730-metric ton (800-ton) per hour crushers would be included in the coal handling system, and would contain chutes, crusher surge bin, feeders to regulate flow to the crushers, and bypass chutework to divert coal directly to the plant supply system. The conveyors associated with unit train unloading facilities should match the unloading systems in capability. A 3,200-metric ton (3,500-ton) per hour rate will be required when the unloading system that is presently under construction is modified for expansion to serve the new generating units. [A 1,590-metric ton (1,750-ton) per hour conveying rate would have been adequate for the trestle dump unloading system.] The emergency stockout system will include a fixed boom cantilevered conveyor and telescopic dust chute capable of building a conical coal pile of about 13,600 metric tons (15,000 tons).

9.3.4 COMPARATIVE ANALYSIS OF ALTERNATIVES CONSIDERED

Figure 9.3-1 summarizes siting and major element alternatives of coal handling facilities. Location variation 1c was the preferred plant location at the Crystal River site (see Section 9.2, Plant Location and Layout Alternatives). Plan XI, which is outlined in Table 9.3-1, was the preferred layout plan. This alternative is the most workable plan of the two possibilities for location 1c (see Table 9.3-1) and results in less impact to coastal wetlands.

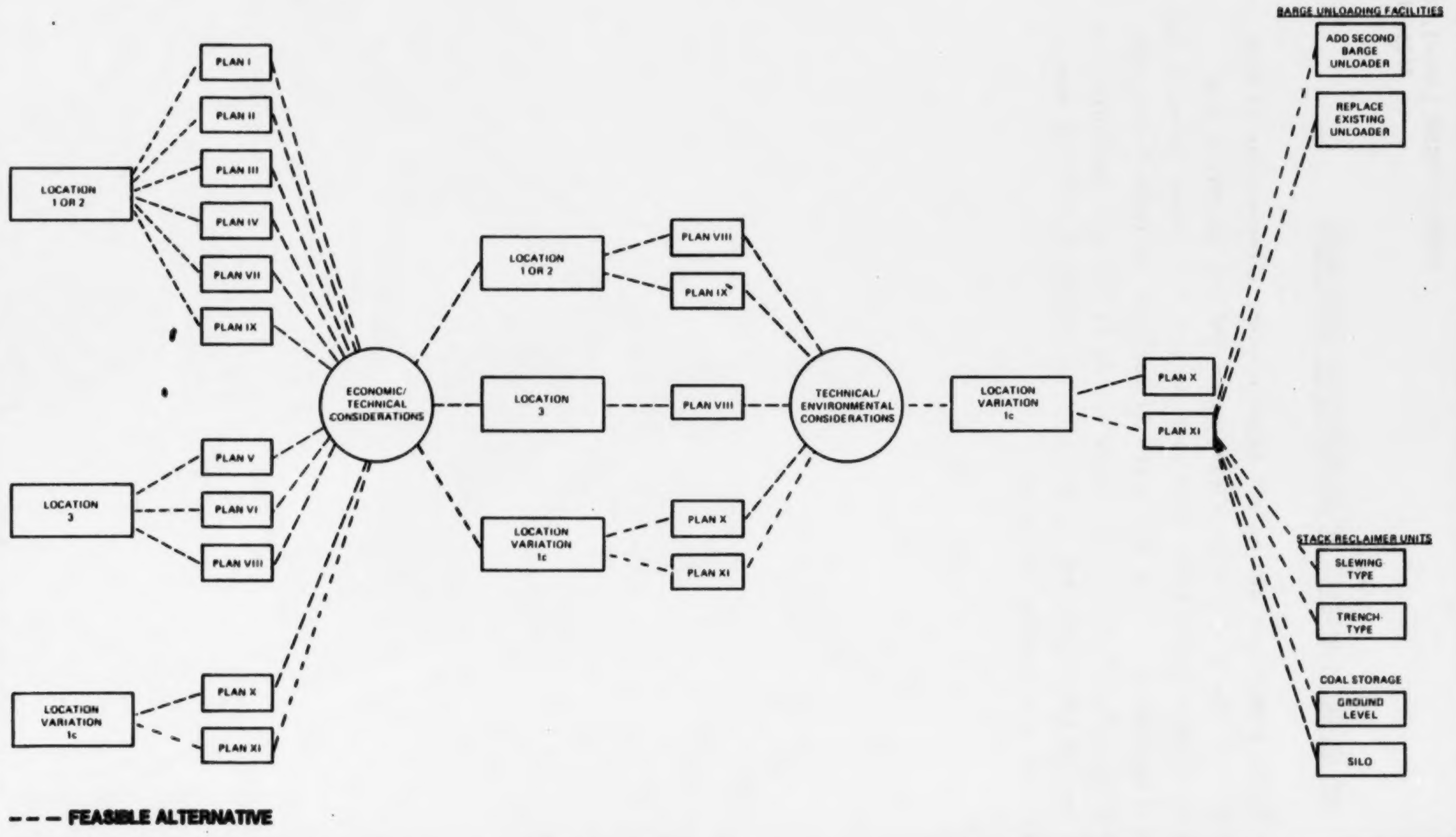

Figure 9.3-1

COAL HANDLING FACILITIES SITING AND MAJOR ELEMENTS ALTERNATIVES DIAGRAM
(see Table 9.3-1 for outline of Plans I-XI)

SOURCE: Environmental Science and Engineering, Inc., 1978

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9.4 WATER SOURCE AND INTAKE ALTERNATIVES

9.4.1 OBJECTIVES

The objectives of this section are to present possible alternative water sources and associated intake designs for the proposed electric generating facility. Clearly, both the water source and intake design are related to the cooling system design ultimately selected. If a large volume of water is required by the selection of once-through cooling or power spray modules, some water sources will not be able to provide the required water. If cooling towers are used, several other water sources become viable alternatives because they can reasonably provide the smaller water volumes which are needed by cooling tower systems.

The alternative designs for cooling water systems are presented in Section 9.5 of this document. In this section, as water sources and intakes are discussed, the cooling system compatible with each source will be identified.

9.4.2 EVALUATION CRITERIA

WATER QUANTITY

Cooling water is required for the generating unit main condenser and the auxiliary cooling system. The alternative cooling systems are described in Section 9.5. Water requirements for condenser cooling vary depending upon water source and cooling system design.

High purity water is required for makeup to the steam generator. The steam flow at rated load is estimated to be 2.23 x 10^6 kilograms (4.91 x 10^6 pounds) per hour per unit. One percent of this value is assumed to be required for replacement of leakage. An additional quantity is required to replace steam lost during each soot blowing cycle. A total of approximately 1 cubic meter (250 gallons) per minute as an average daily flow is required per unit for steam supply makeup.

Bottom ash will be transported to a dewatering bin in a water slurry. This water will be delivered from the service water system and will be recycled. Fly ash will be transported dry to silos.

Potable water is required for sanitary services, cafeteria, drinking, washrooms, and showers. General plant use includes wash water and fire service.

The estimated service water demands for Units 4 and 5 are tabulated in detail in Chapter 3 of this report.

WATER QUALITY

Guidelines used for recirculating water quality limitations are given in Table 9.4-1.

Table 9.4-1 Recirculating Water Quality Limitations

Characteristic	Limitation	Comment
pH and Hardness	Langelier Saturation Index = 1.0	Langelier Saturation Index = pH-pHs where
pH and Hardness with addition of proprietary chemicals for deposit control	Langelier Saturation Index = 2.5	pH = measured pH pHs = pH at saturation with $CaCO_3$ See Sisson for nomagraph solution.
Sulfate and Calcium	$(C_{SO_4}) \times (C_{Ca}) = 500,000$	C_{SO_4} = concentration of SO_4 in mg/l C_{Ca} = concentration of Ca in mg/l as $CaCO_3$
Silica	$C_{SiO_2} = 150$	C_{SiO_2} = concentration of SiO_2 in mg/l
Magnesium and Silica	$(C_{Mg}) \times (C_{SiO_2}) = 35,000$	C_{Mg} = concentration of Mg in mg/l as $CaCO_3$

Source: U.S. EPA, 1973.

9.4.3 WATER SOURCE ALTERNATIVES CONSIDERED

Water source alternatives considered ranged from salt water to brackish water to fresh water. For purposes of discussion, water sources were categorized as fresh water or salt water. The following sources were considered:

Fresh Water	Salt Water
Crystal River	Gulf of Mexico
Withlacoochee River	Withlacoochee Reach of Barge Canal
Lake Rousseau	Saline Aquifer (deep wells)
Freshwater Aquifer (shallow wells)	

FRESHWATER ALTERNATIVES

Freshwater sources include the Crystal River, 4.8 kilometers (3 miles) to the south, and the Withlacoochee River and Lake Rousseau, 6.4 and 5.8 kilometers (4 and 3.6 miles) to the north and northwest, respectively, and a well field 9.2 kilometers (5.7 miles) to the east of the plant site (Figure 9.4-1). In each case, 76.2-centimeter (30-inch) diameter reinforced concrete pipe would be used to convey the raw water to the plant site. Only closed-cycle cooling would be possible using fresh water.

Crystal River

Crystal River as a source of cooling water was considered with an intake structure at a site approximately 4 kilometers (2.5 miles) downstream (west) of the town of Crystal River. The Crystal River runs from several head springs at Kings Bay, westward to the Gulf of Mexico. The maximum flow during normal tides is about 112 cubic meters (4,000 cubic feet) per second, 9,780,000 cubic meters (2,584 million gallons) per day. Interactions of wind and tidal forces result in complex mixing processes between fresh spring water and estuarine water causing large salinity

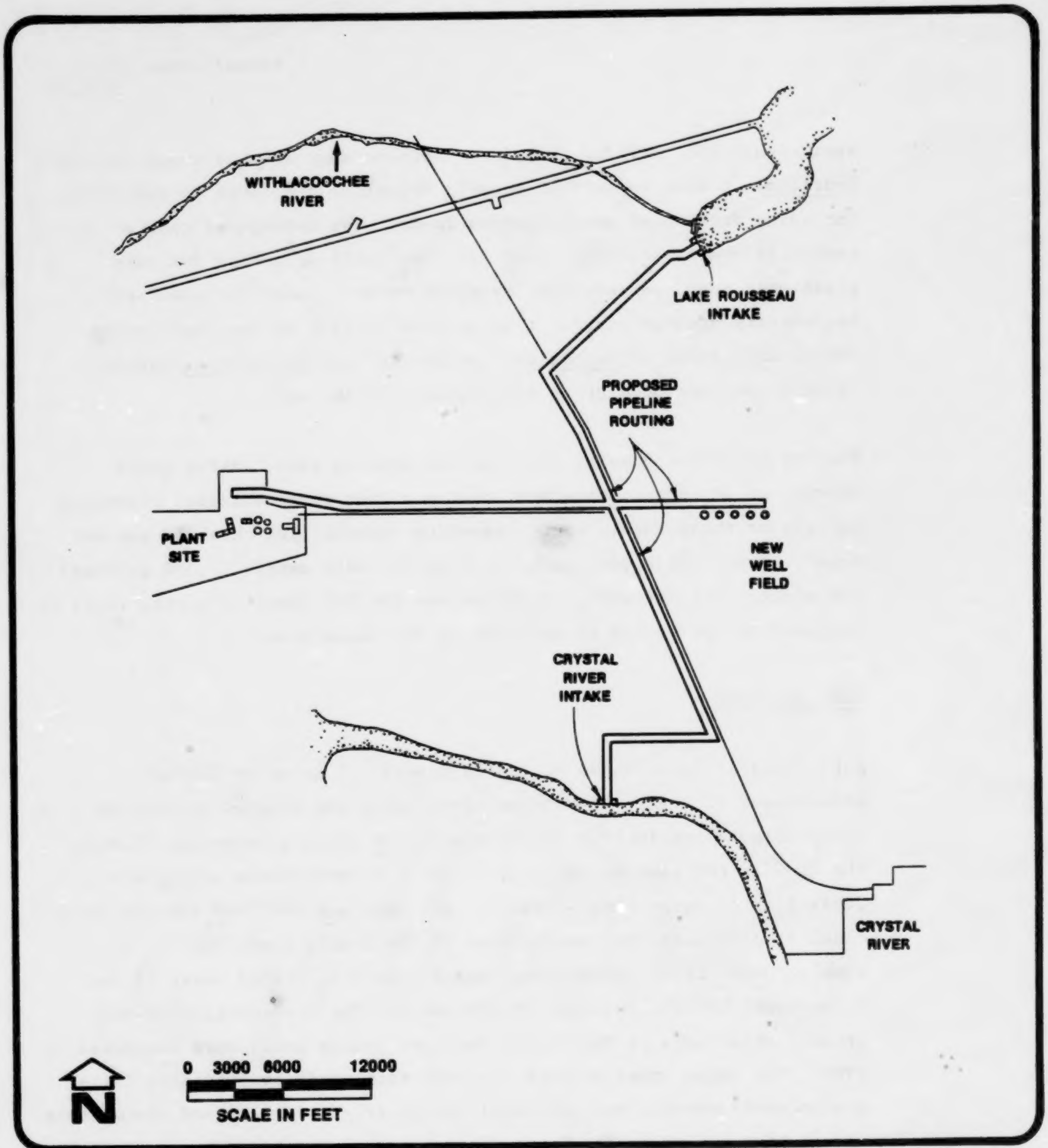

Figure 9.4-1
FRESHWATER SOURCE LOCATIONS

SOURCE: BLACK AND VEATCH, 1969
ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1980.

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variations (ESE, 1977). The river contains many aquatic weeds including *Hydrilla*. A wide variety of aquatic organisms are found in the river including freshwater and estuarine forms. The endangered manatee is common in the river. The river acts typically as a home for many planktonic eggs, larvae, and juveniles of many estuarine species. Preliminary studies suggest that at some seasons of the year, young, entrainable forms of *Anchoa* sp. (anchovies) and *Callinectes sapidus* (blue crabs) are present at the proposed intake site.

The Crystal River pumping facility for cooling water makeup would consist of an intake structure housing either three vertical traveling screens or three double entry traveling screens with three 50 percent capacity vertical pumps, each rated at 28 cubic meters (7,500 gallons) per minute. Approximately 16,500 meters (54,000 feet) of piping would be required to convey the river water to the plant site.

Lake Rousseau

Lake Rousseau (also known as Inglis Reservoir) is an artificial impoundment of the Withlacoochee River which was created by Florida Power Corporation in 1909 for hydroelectric power generation. During the 1960's, the lake became part of the U.S. Army Corps of Engineers Cross Florida Barge Canal project. The lake was modified for the barge canal project with the construction of the Inglis Lock, the Withlacoochee River Bypass Canal and the Gulf of Mexico reach of the barge canal (which lies west of the lake). The construction of the present structures at the Inglis Lock and bypass canal were completed in 1969. The barge canal project has been terminated by President Carter due to environmental and political controversy. Studies and discussions are in progress to decide final disposition of the barge canal project including those structures on or abutting Lake Rousseau.

An area of the lake east of the Inglis Dam has been chosen by Florida Power as the general location of a proposed cooling water intake structure. This area extends from the dam upstream about 2.4 kilometers

(1.5 miles) and has been the site of detailed multidisciplinary studies by ESE (1978).

The lake is part of a system modified by the construction of the Withlacoochee Reach of the Cross Florida Barge Canal. Opening of the canal and a northern bypass for the Withlacoochee River has considerably reduced the flow of water through the southwestern arm of the lake where an intake is presently proposed. Drawing the water volume estimated by Black and Veatch (1977) for cooling would increase the flow in this arm of the lake. This would perhaps resuspend sediments currently stored on the lake bed but ultimately may cause hydrodynamic conditions in the lake to be more like those before the Inglis Bypass was opened.

The bathymetry of Lake Rousseau is shown as a drowned river valley. Depth contours are widely spaced from the shoreline to the old river channel. At the river channel the isobaths are closely spaced indicating a V-shaped channel. The old river channel meanders tortuously through Lake Rousseau indicating a complete lack of structural and bedrock control. Several meander "necks" and "cutoffs" (as defined by Thornbury, 1954) indicate that the Withlacoochee was developing a valley flat prior to its flooding.

By planimetry the volume of Lake Rousseau [at 8.2 meters (27 feet) mean sea level] was found to be in excess of 3.1 x 10^7 cubic meters (25,000 acre-feet). The surface area of the lake, excluding marshy areas, is approximately 1,200 hectares (3,000 acres). Compared to the annual excess flow through the lake of 9.0 x 10^8 cubic meters per year (730,000 acre-feet/year, Geraghty and Miller, 1977), the storage volume is small. This fact is critical in assessing the availability of water in the lake for consumptive use (ESE, 1978).

Sufficient water appears to be available from Lake Rousseau for cooling purposes. Based on USGS figures, the proposed project would require a maximum consumptive use of 76,000 cubic meters (20 million gallons) per day; and according to USGS figures, this is 3.3 percent of the Withlacoochee River 100-year low flow (ESE, 1977).

Shallow Well Fields

Well fields were discussed as an alternative in a report prepared by Geraghty and Miller, Inc. (1977), consulting groundwater geologists and hydrologists.

The well field would be located 8.7 kilometers (5.4 miles) east of the plant site to minimize the potential for horizontal saltwater intrusion. The characteristics of the aquifer in the area, as estimated by Geraghty and Miller from a flow net analysis, should be adequate to support the proposed withdrawal.

An aquifer test performed by Geraghty and Miller (1978) obtained much lower transmissivity values suggesting that groundwater flow to Crystal River may occur through solution channels or local zones of high permeability.

If high transmissivity zones were encountered in the well field, the field could require as few as five wells. However, in the absence of verification of this transmissivity data and based upon aquifer coefficients from the aquifer test, the conceptual well field would require a linear arrangement of 139 wells spaced 152 meters (500 feet) apart in order to produce the desired yield of 76 million liters per day (20 million gallons per day) and comply with Southwest Florida Water Management District Rules and Regulations. Each well would produce 380 liters per minute (100 gallons per minute). The transmission line would amount to approximately 21 kilometers (13 miles) of pipe in the well field itself and another 8 kilometers (5 miles) of pipe to convey the water to the plant site.

Withlacoochee River

The Withlacoochee River is 6.4 kilometers (4 miles) to the north of the Crystal River plant site. It drains an area of approximately 518,000 hectares (1,280,000 acres) in its 256-kilometer (159-mile) course. Average discharge is about 1,938 cubic meters (512,000 gallons) per minute. Most of this flow goes into Lake Rousseau which has inundated a stretch of the old river channel. The majority of the inflow to Lake Rousseau goes into the barge canal and is then diverted above the Inglis Lock into the Withlacoochee Bypass Canal and is discharged back into the existing river channel downstream from Lake Rousseau. About 723 cubic meters (191,000 gallons) per minute below the Inglis Dam is diverted back into the barge canal.

Although no pumping facilities design is available at this time, it is assumed that it would be similar to the one proposed for the Crystal River pumping facility.

SALTWATER ALTERNATIVES

Sources of saltwater or brackish water cooling are (1) the Gulf of Mexico, (2) the Withlacoochee Reach of the Cross Florida Barge Canal, and (3) the saline aquifer (deep wells).

Gulf of Mexico

The Gulf serves as a cooling source for existing units 1, 2, and 3 through a once-through cooling system. In this area, the Gulf ranges in salinity from about 18 ppt to 27 ppt and in temperature from 14 to 30°C (57 to 86°F)(Grimes, 1971).

The mean tidal range for the area is about 1 meter (3 feet). The bottom is gradually sloping in a manner typical of the drowned limestone plateau of west-central Florida. In-shore shallow flats are often exposed at low tide. These areas are bottom dominated by dense summer growths of marine grasses. More seaward, the depth drops to about 2 meters (6.6 feet) and phytoplankton of drifting green plants take over more of a role in primary production. Coastal marshes are extensive and dominated by Juncus (McKellar, 1974).

The Gulf of Mexico can provide the necessary quantities of water for once-through cooling, cooling tower makeup water, or for the use of power spray modules with dilution. Water may be obtained either from the existing intake or existing discharge canal.

Withlacoochee Reach of Cross Florida Barge Canal

The Withlacoochee Reach of the Cross Florida Barge Canal was created by the Corps of Engineers as part of the initial construction of the Gulf Reach of the Cross Florida Barge Canal. Fresh water enters this section of the canal by infiltration from the surficial aquifer, by seepage through the Inglis Dam and the Inglis Lock, and by discharge of high river flow over the Inglis Dam spillway. Saline water from the open Gulf is exchanged with fresh water as a result of the tidal and wind forces.

It is not known at this time what effect withdrawing sufficient quantities of cooling water from the canal would have on Gulf and freshwater inflows into the canal. However, because the canal is open-ended on the Gulf, the canal can provide the necessary quantities of water.

Deep Aquifer

Underlying the freshwater aquifer is water of higher salinity. The potential yield and quality of water are largely unknown. However, if suitable freshwater sources could not be made available, and entrainment and impingement impacts of drawing open Gulf water were considered significant as additional units were proposed to come on line, then this source could be considered feasible. More testing and investigation needs to be done before specific consideration and design parameters could be given for this source.

9.4.4 INTAKE STRUCTURE ALTERNATIVES CONSIDERED

Consideration of required intake designs falls into two general classes. These classes are: (1) large-volume intakes, and (2) lower volume intakes. Large volume intakes would be required if once-through or power spray modules were used for condenser cooling. Such systems would be realistic only if makeup water were taken from the Gulf of Mexico or the Withlacoochee Reach of the Cross Florida Barge Canal, where the large volumes of water needed would be available. Lower volume intakes would be required for cooling tower makeup water from either fresh or saltwater sources. The amounts of water required for cooling tower makeup are considerably less than the amounts required for once-through cooling or power spray modules. At this point in the analysis, the full list of water sources discussed in the preceeding section will be considered feasible sources for the quantities of water which would be needed for cooling tower makeup.

Intake structures are not required for groundwater makeup sources such as shallow or deep saline aquifer well fields. Alternative intake design for these sources is not discussed further.

LARGE-VOLUME INTAKES

Many designs for intake structures which might mitigate environmental impacts are prohibitively expensive for cooling systems which require large amounts of water. Such systems include once-through cooling and power spray modules with dilution. For these cooling systems the existing intake canal is indicated as the technically feasible source water (Black and Veatch, 1976). Other methods of obtaining water would require rather large alterations, including additional dredging. Such possibilities would include new canals, lengthy pipe systems, and modification of the Withlacoochee Reach.

Depth placement of the intake structure in the intake canal does not appear to be useful in limiting entrainment. Zooplankton populations were not found to be vertically stratified at Crystal River (Maturo, et al., 1974). Designs should be concerned mainly with limiting impingement.

An inlet flush with the side of the canal would be superior to an inlet placed at the end of an open channel. The flow in the intake canal would help direct finfish and shellfish past the screens instead of into them. With additional intake structures on the bank of the intake canal, it does seem possible that impingement could increase at Units 1, 2, and 3. Organisms tired or injured by the intake of Units 4 and 5 would be more easily carried into the screens of the existing units.

Designs such as inclined or horizontal traveling screens or perforated pipe intakes would also serve to reduce impingement. These methods would be expensive but would allow moving organisms some alternate route away from the screens.

If vertical screens are to be used, the impacts can be minimized by operating the screens continuously and providing a path for gentle and rapid return of impinged creatures to the water. Vertical screens could also be placed at an angle to the flow and lead fish into a bypass system.

LOWER VOLUME INTAKES

Water requirements for cooling tower makeup are considerably less than for once-through or power spray modules with dilution. Crystal River, Lake Rousseau, the Withlacoochee River, the Gulf of Mexico, and the Withlacoochee Reach of the Cross Florida Barge Canal will, at this point in the analysis, be considered feasible sources for cooling tower makeup.

Crystal River

The Crystal River intake system will be supplemented by two 5.7 cubic meters (1,500 gallons) per minute wells that would supply potable water to the plant site. Eleven years of record show the river minimum level to be about 0.9 meters (3 feet) below mean sea level and maximum level to be about 1.8 meters (6 feet) above mean sea level.

One alternative design for a Crystal River intake is conventional vertical traveling screens. The vertical traveling screen intake structure would consist of three 1.5-meter (5-foot) wide screens at an approach water depth of 2.4 meters (8 feet). Each screen would be placed in approximately a 1.7-meter (5-foot, 6-inch) wide pump bay.

The overall structure would be approximately 6.1 meters wide by 7.6 meters long by 6.1 meters high (20 feet wide by 25 feet long by 20 feet) high. The remaining components of the vertical traveling screen intake would be the same as for Lake Rousseau except for the material used for the components. The brackish water of Crystal River would require the use of corrosion-resistant material for the screens and framing.

A double entry vertical traveling screen for Crystal River would be located in a conventional concrete structure. The overall arrangement is similar to the double entry vertical traveling screen for Lake Rousseau. The only difference would be the corrosion-resistant materials and coatings of the components for the Crystal River intake.

The perforated pipe intake system for Crystal River will be the same for Lake Rousseau. A perforated pipe intake system operates more efficiently in a river because the current carries the backwashed debris away, thereby reducing the number and length of backwashes.

One difference from Lake Rousseau would be the orientation of the perforated pipes. In Crystal River, the perforated pipes would be oriented parallel with the current and offset so that a water craft could only damage one perforated pipe.

Lake Rousseau

Lake Rousseau is expected to have a severe weed problem. Both floating seasonal weeds and a submerged type of vegetation must be controlled at the intake site. Eleven years of record show the lake minimum level to be about 6.7 meters (22 feet) above mean sea level and maximum level to be about 8.5 meters (28 feet) above mean sea level.

A vertical traveling screen intake structure in Lake Rousseau would require three 0.9-meter (3-foot) wide screens at an approach water depth of 3.6 meters (12 feet). Each screen would be placed in approximately a 1.7-meter (5-foot, 6-inch) wide pump bay.

The overall intake structure would be approximately 6.1 meters wide by 7.6 meters long by 6.1 meters high (20 feet wide by 25 feet long by 20 feet high). The structure would also house the trash racks and mechanical rake to protect the screens from heavy debris, as well as contain the stop logs.

A differential controller would control the operation of the screens. The controller would start the screen drive and the spray pump at a predetermined headloss across the screens.

The entire intake system is remotely operated except for the mechanical trash rake and debris disposal. When trash removal is required, an operator must operate the mechanical rake and dispose of the trash and the accumulated screened debris.

Open water type double entry vertical traveling screens in Lake Rousseau would be mounted on a platform. The platform would be about 7.6 meters by 11 meters (25 feet by 35 feet) and would be located over approximately 4.6 meters (15 feet) of water. The platform would support the three 30 cubic meters (8,000 gallons) per minute pumps and three 0.9-meter (3-foot) wide screens, each directly connected to a pump.

A perforated pipe intake system would require two perforated pipes approximately 110 centimeters (42 inches) in diameter. The pipes would be located in approximately 2.4 to 4.6 meters (8 to 15 feet) of water, approximately 0.6 meters (2 feet) from the bottom and pin jointed to the main feeder pipes that supply water to the pump structure. The feeder pipes would be approximately 91 centimeters (36 inches) in diameter and about 61 meters (200 feet) long.

Backwash for the perforated pipes would be done by a valving arrangement that would allow two of the pumps to backwash one of the perforated pipes at a time. A differential head controller would be used to determine when backwashing of the perforated pipes is required. The pump structure would be located on shore and would support the three 30-cubic meter (8,000-gallons) per minute pumps.

Withlacoochee River

Specific designs for intake structures in the Withlacoochee River are not available. Vertical traveling screens, double entry vertical traveling screens, and perforated pipe designs similar to those suggested for Crystal River would be possible.

Gulf of Mexico

Gulf of Mexico waters could be taken in by an intake structure located on the existing intake or discharge canals. Locating the intake on the existing discharge canal would have environmental advantages since the water entrained would have already passed through the cooling systems of Units 1, 2, and 3. Units 4 and 5, therefore, would not impact additional water over that already impacted by Units 1, 2, and 3. Such an intake would be closer to Units 4 and 5 and thus would reduce the cost of piping; but, because the water is also hotter, the plant would be subjected to engineering penalties.

Three alternative methods of locating the intake structure are available, either on the existing intake canal or on the discharge canal. The inlet could be flush with the canal shoreline; the inlet could be set off the canal shoreline in open water; or the inlet could be set back from the existing canal at the end of a new channel.

An intake structure on the existing discharge canal would provide makeup water for saltwater cooling towers. Required volumes would be about 68,000 gallons per minute. The structure would be about 50 feet in width and would be divided into three cells. Given the amount of water required, it should be possible to keep maximum velocities below 0.5 feet per second.

Withlacoochee Reach of Cross Florida Barge Canal

Specific designs for intake structures are not available for this water source. Intake for cooling tower makeup water would be similar to those suggested for Crystal River.

9.4.5 COMPARATIVE ANALYSIS OF ALTERNATIVES CONSIDERED

ECONOMIC CONSIDERATIONS

Comparative capital and annual costs of alternative freshwater supply sources are given in Table 9.4-2 and 9.4-3. Data were not available for the Withlacoochee River as a source.

The Crystal River source has the highest capital cost of the three freshwater water supply sources considered, as well as the highest total annual cost. The primary reason for the higher costs is Crystal River alone would not provide proper quality of raw water, and use of freshwater wells for stream cycle makeup water would have to be provided. Costs for development of the Withlacoochee River would probably be between the costs for use of Crystal River and Lake Rousseau; depending, of course, on detailed analysis of quantity available (possible well field subsidy as required for Crystal River) and additional piping requirements.

Cost data for saltwater sources specific to the proposed site are available only for the Gulf of Mexico. These data can be extracted from the section on alternative cooling systems, Tables 9.5-3 through 9.5-11. Major costs would be for the intake system and canal work to modify existing canals. Total capital costs for Gulf of Mexico source drawn through the existing canal system are generally less than $10,000,000 for any of the proposed cooling alternatives. Annual maintenance costs range from $40,000 to $100,000 per year depending on the cooling alternative. Site specific cost data were not available for the following additional saltwater source alternatives: Withlacoochee Reach of the Barge Canal or deep wells (saline aquifer). Undoubtedly, all of these later alternative sources will be more expensive than the Gulf source. Mixing of fresh and salt water in the Cross Florida Barge Canal would result in changing water quality. Distance from the power plant and the need for acquiring rights-of-way, and future uncertainties as to the

Table 9.4-2 Comparative Capital Costs--Alternative Water Supply Sources--Crystal River Units 4 and 5

Requirement	Water Source Crystal River	 Lake Rousseau	 Well Field
Piping from Wells	$1,685,000	$ 0	$4,275,000
Piping from Intake	5,405,000	4,800,000	0
Intake Structure	531,000	525,000	0
Wells	154,000	0	604,000
Subtotal	7,775,000	5,325,000	4,879,000
Differential	2,896,000	446,000	Base
Escalation (23 percent)	660,000	103,000	Base
Subtotal	3,556,000	549,000	Base
Interest During Construction (15 per cent)	534,000	82,000	Base
Indirect Costs (8.7 per cent)	309,000	48,000	Base
Total	4,339,000	579,000	Base

Source: Black and Veatch, 1977.

Table 9.4-3 Comparative Annual Costs--Alternative Water Supply Sources--Crystal River Units 4 and 5

	Water Source		
Requirement	Crystal River	Lake Rousseau	Well Field
Operating Costs			
Energy	$ 75,000	$ 21,000	Base
Chemical	88,000	Base	$146,000
Demand Charges	7,000	2,000	Base
Fixed Charges at 14 percent	616,000	95,000	Base
Total	786,000	118,000	146,000
Differential	668,000	Base	28,000

Source: Black and Veatch, 1977.

dispensation of the canal could add to the cost of this alternative. Costs for deep wells would be similar to those for the shallow (freshwater) field, only higher, due to increased drilling and piping costs, and varying quality of the source.

Without site-specific cost data for each alternative source considered, a strict ranking relative to cost can be offered only as a "best guess." However, site specific estimates for the most apparent cost-effective source alternatives were included. A relative ranking of alternatives according to lowest estimated cost (or in cited cases, speculated cost) is:

Gulf of Mexico
Lake Rousseau
Shallow wells (freshwater)
Withlacoochee Reach Cross Florida Barge Canal
Crystal River
Withlacoochee River
Deep Wells (saline water)

Cost data for alternative intake structures are given in Tables 9.4-4, 9.4-5, and 9.4-6. Perforated pipe rank lowest in cost with vertical traveling screens and double-entry vertical traveling screens second and third, respectively. Cost data were not available for inclined and horizontal traveling screens.

TECHNICAL CONSIDERATIONS

Technical considerations are primarily centered on water quality characteristics of each alternative water source and upon a comparison of power plant water needs and present water use in the area.

Projected consumptive use requirements for competing users of all fresh water in Citrus County are listed in Table 9.4-7 (Corps of Engineers, 1977). The total projected nonpowerplant requirements for ground water

Table 9.4-4 Capital Cost Summary Alternative Intake and Discharge Systems—Crystal River

Item	Vertical Traveling Screens ($)	Perforated Pipe ($)	Double Entry ($)
Well system*	Base	Base	Base
Structure	103,000	Base	95,000
Screening device	52,000	Base	61,000
Pumping system	Base	Base	Base
Subtotal	155,000	Base	156,000
Escalation at 7.2%	11,000	Base	11,000
Indirect costs at 8.7%	14,000	Base	15,000
Interest during construction at 51%	85,000	Base	85,000
Total	265,000	Base	267,000
Differential	265,000	Base	267,000

*The cost of the two 5.7 cubic meters (1,500 gallons) per minute wells and their associated piping is included in the cost for all alternatives for Crystal River.

Source: Black and Veatch, 1978.

Table 9.4-5 Capital Cost Summary Alternative Intake and Discharge Systems—Lake Rousseau

Item	Vertical Traveling Screens ($)	Perforated Pipe ($)	Double Entry ($)	Double Open Water ($)
Structure	103,000	Base	95,000	—
Platform	—	—	—	350,000
Screening device	Base	21,000	9,000	29,000
Pumping system	Base	Base	Base	Base
Subtotal	103,000	21,000	104,000	379,000
Escalation at 7.2%	7,000	2,000	7,000	27,000
Indirect costs at 8.7%	10,000	2,000	10,000	35,000
Interest during construction at 51%	56,000	11,000	57,000	207,000
Total	176,000	36,000	178,000	648,000
Differential	140,000	Base	142,000	612,000

Source: Black and Veatch, 1978.

Table 9.4-6 Annual Cost Summary Alternative Intake and Discharge Systems

Item	Vertical Traveling Screens ($)	Perforated Pipe ($)	Double Entry* ($)	Double Open Water* ($)
Lake Rousseau				
Energy	4,000	Base	4,000	4,000
Demand Charges	1,000	Base	1,000	1,000
Fixed Charges	20,000	Base	20,000	86,000
Differential Annual Cost	25,000	Base	25,000	91,000
Crystal River				
Energy**	4,000	Base	4,000	—
Demand Charges	1,000	Base	1,000	—
Fixed Charges	37,000	Base	37,000	—
Differential Annual Cost	42,000	Base	42,000	

*The energy costs include operating the screen drive and spray pumps.

**The energy costs associated with operating the two 5.7 cubic meters (1,500 gallons) per minute wells is included in all alternatives for Crystal River.

Source: Black and Veatch, 1978.

Table 9.4-7 Present and Projected Future Freshwater Demands in Citrus County, in Cubic Meters per Day (Million Gallons per Day)

	Groundwater Demand 1976		Projected Water Demand 1985		Projected Water Demand 2035	
	cmd $x10^3$	mgd	cmd $x10^3$	mgd	cmd $x10^3$	mgd
Municipal	14.8	(3.9)	26	6.8	87.4	23.1
Industrial*	31	(8.2)	29	7.7	7.6	2.0
Agricultural	42	(11.1)	45	12.0	101	26.7
TOTAL	87.8	(23.2)	100	26.5	196.0	51.8

*Excludes power plant demands.

Source: Geraghty and Miller, 1977.

and surface water to the year 2035 is 196,000 cubic meters per day (51.8 million gallons per day). Projected cooling tower makeup needs for the proposed project will increase consumptive use requirements in Citrus County to 272,000 cubic meters per day (71.8 million gallons per day). Consequently, power plant usage represents approximately 28 percent of the total surface and groundwater demand. Agricultural and municipal consumptive use will account for 69 percent of demand.

Crystal River

Water samples were collected by Florida Power Corporation at three points at low, flood, high, and ebb tide conditions on Crystal River. The water quality data listed in Table 9.4-8 are from the sample point nearest the proposed intake structure location. Comparison of the listed concentration values indicates the tidal influence. The daily variations in water quality and the poor quality of the water makes this an undesirable source of cooling tower makeup and an unsatisfactory source for service water. With Crystal River as the source, control of cooling water quality would be difficult. Total dissolved solids concentrations, as well as chloride and sulfate concentrations, make the water unsuitable as a potable water supply.

With Crystal River as the source of makeup, a maximum of five cycles of concentration can be maintained in the cooling water system. The estimated maximum and average station water requirements for Crystal River source are presented in Table 9.4-9.

Extensive pretreatment of the river water source would be required prior to use as service water. Clarification, lime softening, and filtration would not provide a water suitable for potable use or for supply to the ion exchange system. To produce suitable water, an additional step such as reverse osmosis would be required. The variable river water quality would make control of process equipment difficult.

Table 9.4-8 Crystal River Water Analyses

Constituent	Low	Flood	High	Ebb
Calcium*	163	130	200	140
Magnesium*	312	300	353	345
Sodium*	1,838	1,806	4,289	2,092
Potassium*	47	42	83	52
M-alkalinity*	127	133	183	134
Sulfate*	212	215	464	246
Chloride*	2,021	1,930	4,323	2,249
Silica†	6.4	6.4	6.0	6.2
Specific Conductance, umhos	3,817	3,846	6,061	4,464
pH	8.1	8.1	8.1	8.1

*mg/l as $CaCO_3$
†mg/l as SiO_2

Source: Black and Veatch, 1977.

Table 9.4-9 Estimated Station Water Requirements Crystal River Units 4 and 5

	Water Source					
	Crystal River gpm		Lake Rousseau gpm		Well Field gpm	
Requirement	Avg.	Max.	Avg.	Max.	Avg.	Max.
Cooling Tower Makeup	9,200	13,750	8,300	12,400	8,850	13,200
Service Water	400	1,000	400	1,000	400	1,000
Raw Water	100	300	100	300	100	300
Total	9,700	15,050	8,800	13,700	9,350	14,500

Source: Black and Veatch, 1977.

Crystal River does not have a water supply sufficient for use in power spray module cooling. The 1,000 gpm (1,440 mgd) described by Black and Veatch (1976) amounts to about 64 cubic meters (2,300 cubic feet) per second (1,486 mgd). A maximum water supply of about 100 cubic meters (4,000 cubic feet) per second (2,584 mgd) is available at Crystal River (ESE, 1977).

Cooling towers with Crystal River makeup water would not require as large a volume of water as cooling with estuarine waters [.037 cubic meters per minute/53 cubic meters per day (9,700 gallons per minute/ 14 million gallons per day) average, 83 cubic meters per day/.058 cubic meters per day (15,000 gpm/22 mgd) maximum] (Black and Veatch, 1977). However, salinity fluctuations require a larger volume of makeup water from Crystal River than would be needed from either Lake Rousseau or the well fields.

Lake Rousseau

Water quality data for Lake Rousseau are presented in Table 9.4-10. These data were taken from analysis of the samples collected by Florida Power Corporation and from data compiled by the USGS during 1975. The minimum and maximum concentrations found in these data are tabulated, along with the analysis of a typical sample. The lake water is of acceptable quality to serve requirements, with pretreatment of the service water supply.

An average of nine cycles of concentration can be maintained in the cooling water system when using Lake Rousseau as the makeup water source. The estimated maximum and average station water requirements from the Lake Rousseau source are presented in Table 9.4-9.

The concentrations of dissolved solids in Lake Rousseau are lower than either Crystal River or well fields (Black and Veatch, 1977; ESE, 1977). As mentioned before, this factor partially determines the amount of

Table 9.4-10 Lake Rousseau Water Analyses

Constituent	Minimum	Maximum	Typical
Calcium*	97.5	115	106
Magnesium*	19.3	21.8	21
Sodium*	6.5	7.6	7.4
Potassium*	0	0.3	0.2
M-alkalinity*	97	121	108
Sulfate*	16.6	22.9	19
Chloride*	4.5	10.4	7
Silica†	-	-	1.0
Nitrate	5	7.3	6.3
Specific Conductance, umhos	235	330	266
pH	7.2	8.4	7.8

*mg/l as $CaCO_3$
†mg/l as SiO_2

Source: Black and Veatch, 1977.

water needed. Black and Veatch indicate that less water would be needed from Lake Rousseau [.034 cubic meters per minute/49 cubic meters per day (8,800 gallons per minute/13 million gallons per day) average and .053 cubic meters per minute/76 cubic meters per day (13,700 gallons per minute/20 million gallons per day) maximum] than from well fields [.037 cubic meters per minute/53 cubic meters per day (9.350 gallons per minute/14 million gallons per day) average and .056 cubic meters per minute/17 cubic meters per day (14,500 gallons per minute/21 million gallons per day) maximum].

It would appear that Lake Rousseau waters with lower levels of dissolved solids would need a lower amount of antiscaling chemical treatment.

The chemical characteristics of Lake Rousseau, as listed in USGS data from 1966 through 1975 and as represented by the water sample, are quite consistent. The service water supply would require pretreatment through use of lime softening, clarification, and filtration. Possible organic contamination must be removed by pretreatment before use as potable water and as supply to the demineralization system. Although Lake Rousseau is an acceptable service water source, the possible organic content makes it less suitable than well water.

Shallow Well Field

Well water chemical characteristics based on data provided by Florida Power Corporation are tabulated on Table 9.4-11. These data were derived from analyses of samples from three existing wells. The wells are the present source of fresh water supply to the Crystal River plant.

These analyses indicate some variations in water quality between wells, in addition to some variations for each well. Use of the raw well water as the makeup to the cooling water system would allow up to six cycles of concentration to be maintained. The estimated maximum and average

Table 9.4-11 Well Water Analyses

	Well 3	Well 4		Well 5	
	4/13/76	4/13/76	11/30/76	4/13/75	8/18/75
Calcium*	147	173	160	167	153
Magnesium*	70	74	82	74	82
Sodium*	10	9	9	10	10
M-alkalinity*	208	237	234	232	226
Sulfate*	5	5	5	5	5
Chloride*	13	13	11	13	13
Nitrate	-	-	-	-	-
Silica†	414	-	4.4	4.3	3.9
Specific Conductance umhos	435	485	430	475	440
pH	7.8	7.6	7.8	7.6	7.7

*mg/l as $CaCO_3$
†mg/l as SiO_2

Source: Black and Veatch, 1977.

station water requirements from the well source are presented in Table 9.4-9.

Operation of the existing pretreatment system on the present well water supply demonstrates the expected success of providing a suitable service water by lime softening and filtration. The water supply has been satisfactory as supply to the existing demineralization system and potable water systems. The service water system for the new generating units would require a similar pretreatment process if well water is used in conjunction with Crystal River water.

Withlacoochee River

Chemical characteristics of Withlacoochee River water are presented in Table 9.4-12. Lower levels of dissolved solids are present than in either well water or the waters of Lake Rousseau, although specific conductance is higher in the river, based upon these data. Given the uncertain plans for this area of the Withlacoochee and the relatively low flows available through the Inglis lock, this source does not appear dependable enough as a source for cooling tower makeup.

Withlacoochee Reach of Cross Florida Barge Canal

Chemical characteristics of the Withlacoochee Reach of the Cross Florida Barge Canal are presented in Table 9.4-13.

Gulf of Mexico

The use of saline estuarine water in cooling tower makeup would require larger volumes of estuarine water than if fresh water were used. Black and Veatch (1976) estimate that some .17 cubic meters per minute/245 cubic meters per day [45,000 gallons per minute (64.8 million gallons per day)] would be required for a natural draft tower using estuarine water, while less than .04 cubic meters per minute/54.5 cubic

Table 9.4-12 Withlacoochee River Water Analysis, Bypass Channel Below Structure

Constituent	Concentrations High Flow	Concentrations Low Flow
Calcium, mg/l	41	36
Magnesium, mg/l	5.7	4.0
Bicarbonate, mg/l as HCO_3	131	—
Carbonate, mg/l as CO_3	0	—
Alkalinity, mg/l as $CaCO_3$	108	—
Chloride, mg/l	16	6.1
Specific Conductance, umhos	352	229
pH	7.7	7.8
Suspended sediment, mg/l	9.7	—

Source: Environmental Science and Engineering, Inc., 1977 (based on USGS, 1976).

Table 9.4-13 Cross Florida Barge Canal Water Analysis at Inglis Lock

Constituent	Concentrations Sept/Oct/Nov/Dec	 May
Calcium, mg	140	200
Magnesium, mg/l	310	650
Bicarbonate, mg/l as HCO_3	169	—
Carbonate, mg/l as CO_3	0	—
Alkalinity, mg/l as $CaCo_3$	139	—
Chloride, mg/l	6,800	12,060
Specific conductance, umhos	15,025	25,200
pH	7.7	7.5
Suspended sediment, mg/l	6.7	—

Source: Environmental Science and Engineering, Inc., 1977 (based on USGS, 1976).

meters per day [10,000 gallons per minute (14.4 million gallons per day)] would be needed for fresh water from Crystal River, Lake Rousseau, or well fields (Black and Veatch, 1977). This is because estuarine water contains larger quantities of dissolved solids and can be cycled through the tower fewer times before "blowdown" or discharge. Chemical characteristics of Gulf of Mexico water in the present intake canal are presented in Table 9.4-14.

Deep Aquifer

The chemical makeup and availability of water from deep aquifers is not available.

ENVIRONMENTAL CONSIDERATIONS

All the water sources considered would exhibit some impacts if drawn upon by the power plant. Impacts are, of course, intimately connected to the type of cooling system used and the intake design using the best available technology. There will, as a result, be some overlap between this section and other sections concerning water sources impacts. The major criteria which were considered in the development of this section are entrainment, impingement, water availability, water quality, and circulation. The impacts on the ecology of these waters would include impingement of larger organisms on the screens and entrainment of smaller organisms into the power plant condenser and other structures. Water availability in each source as compared to the need of Florida Power Corporation must also be considered. Another aspect to be discussed is the possible disruption of existing patterns of water quality and circulation in the source body of water.

Cooling towers would require much less water to be entrained while once-through cooling and power spray modules would require considerably more water (Black and Veatch, 1977). Generally, the more water taken in by the cooling system, the more organisms entrained. Entrainment would be

Table 9.4-14 Water Quality Crystal River Plant Station D, Intake Canal, Gulf of Mexico

Date	Salinity 0/00	PO_4-P Parts per 10 million	NO_3-N Parts per 10 million	NH_3-N Parts per 10 million	SiO_2-Si pp ppm	NO_2-N ppb	Organic C ppm
11/6/73	28.117	0.19	0.103	<0.05	0.591	1.0	3.7
11/20/73	29.25	0.08	0.021	0.46	0.367	0.5	6.4
12/3/73	27.627	0.24	0.106	0.36	0.736	7.9	3.15
12/18/73	25.587	0.34	0.066	0.03	0.509	0.8	3.41
1/3/74	22.158	0.18	0.044	0.52	0.295	1.4	4.39
1/14/74	23.873	0.10	0.012	0.05	0.563	0.3	2.87
1/28/74	23.207	0.482	0.008	0.26	0.737	0.2	5.63
2/12/74	23.418	0.14	0.029	0.37	0.755	0.3	6.6
2/27/74	20.563	0.023	No data	0.19	0.377	1.0	6.9
3/13/74	26.484	0.113	0.057	0.56	0.280	0.3	No data
3/26/74	20.075	0.09	0.004	0.68	0.850	No data	6.3
4/9/74	23.121	0.14	0.012	0.44	1.012	0.9	7.6
4/24/74	24.040	0.28	<0.001	0.38	0.805	0.8	12.3
5/7/74	26.046	0.14	0.006	0.43	0.757	0.4	4.9
5/22/74	26.060	0.18	0.022	0.36	1.01	0.3	7.3
6/4/74	25.189	0.21	0.037	0.53	0.966	0.1	6.9
6/21/74	27.627	0.33	0.046	0.35	1.283	0.7	5.9
7/3/74	20.342	<0.01	0.662	1.94	1.252	<0.1	6.3
7/19/74	24.60	<0.01	0.478	0.25	1.522	<0.1	4.9
7/31/74	21.0	12.02	0.630	0.90	0.659	<0.1	8.0
8/16/74	23.8	5.12	0.482	0.51	1.145	<0.1	7.1
8/28/74	25.6	1.71	0.11	0.34	0.410	<1	5.7
9/13/74	25.8	0.18	0.08	0.22	0.184	<1	5.1

Source: Environmental Science and Engineering, Inc., 1977 (based on Florida Power Corporation, 1976).

less for cooling towers. Impingement could be substantially reduced if cooling towers are used, since the required volume of water can be provided with lower intake velocities (EPA, 1976; Boreman, 1977). Circulation, water quality, and water availability impacts are generally directly proportional to the volume of water that will be withdrawn for consumptive use.

Impacts which could take place with groundwater use include horizontal salinity intrusion, vertical upwelling of highly mineralized water through confining zones, consumptive use of freshwater, lowering of surfical water table and interference with surface water flows. Questions of entrainment and impingement of organisms as associated with use of surface water do not apply to groundwater since the organisms are simply not present. Geraghty and Miller estimate that in 1976, groundwater withdrawals in Citrus County for industrial, agricultural, and municipal purposes totaled 87,800 cubic meters (23.2 million gallons) per day (see Table 9.4-7). Withdrawals are not concentrated in any one area.

Potential impacts resulting from well water cooling would be dependent upon the following information:

1. Aquifer characteristics:
    a. Transmissivity;
    b. Storage coefficient;
    c. Thickness, composition, and extent of clay layers between pumping zone and surface waters;
    d. Aquifer leakance values.
2. Wellfield design:
    a. Pumping rates;
    b. Number of wells;
    c. Spacing of wells;
    d. Penetration of aquifer;
    e. Proximity of wells to surface waters; and
    f. Duration of pumping at each well.

Many impacts depend upon information from test pumping. See Section 9.4.3, Shallow Well Fields.

Saline groundwater has also been suggested for cooling tower makeup. This would not amount to a consumptive use of freshwater. High concentrations of minerals present in such water would allow fewer cycles through cooling towers and technical problems may result from corrosion. There are no known power plants which presently employ this source of cooling water.

Use of the existing Withlacoochee Reach of the Cross Florida Barge Canal would result in entrainment as would using Gulf of Mexico water through the present intake canal. Future modifications to the canal reach could reduce this factor, but plans for the disposition of the area are uncertain. The availability of water in this source depends upon technical decisions yet to be made by the state and federal governments concerning the Barge Canal property.

An intake structure at the presently proposed site on Crystal River would have an impact on an area of freshwater marsh. This area is populated by sawgrass and cattails and provides habitats for a number of freshwater fish including the sailfin molly and the mosquito fish (ESE, 1977). The other water source alternatives would not require construction through existing wetlands.

Lake Rousseau impacts would be mainly entrainment of planktonic forms if impingement is considerably reduced, as expected, by proper intake design. Studies are underway to estimate the numbers and types of organisms which would be entrained and any disruption of present circulation patterns in the lake which might result (ESE, 1977).

The life habits of the expected species of freshwater fish in Lake Rousseau are such that few drifting eggs, larvae, and entrainable juveniles would be present in the deeper sections of the lake presently proposed as an intake site (ESE, 1977).

If a best available technology intake is designed, entrainment may be considerably reduced. Organisms entrained could be limited to forms which occupy many important positions in the lake food web, but are not considered commercially or recreationally valuable in themselves (ESE, 1977a; ESE, 1977b). The intake could be placed in deep offshore waters of low biological productivity (ESE, 1977).

The asiatic clam, Corbicula, may cause technical problems if Lake Rousseau is used for cooling tower makeup water. Corbicula is known to occur in the lake (ESE, 1977). Corbicula fluminea is an opportunistic species recently introduced into U.S. waters. It is a species with high reproductive capacity and fast growth which has the ability to colonize power plant condensers. The clam reduces water flow through condenser tubes and prevents laminar flow. The organism is resistant to biocides and can withstand chlorination far above the limits allowed by EPA. Young clams can attach in flows up to 2.2 meters (7.2 feet) per second. Problems may result in discharge waters when many of the clams die at once. The Savannah Nuclear Plant must be shut down periodically for maintenance due to infestations of Corbicula.

Both EPA (EPA, 1976) and U.S. Fish and Wildlife Service (F&WS, 1977) emphasize that the best way to minimize power plant impacts on important aquatic resources is by locating the plant near water where such resources are scarce. These agencies suggest that the best available knowledge of the source water be used by the planner to properly place the intake vertically and horizontally and to arrive at the design which will least affect the aquatic system. In addition, both agencies would like to see designs which limited intake velocities to about 15 centimeters (0.5 feet) per second. This is generally considered to be a flow velocity which most species of fish can resist and avoid impingement.

Placement and design of the intake structure should be fitted to the water needs of the cooling system and the source body of water.

Water volumes required for cooling tower makeup are considerably less than that required for the systems described above (Black and Veatch, 1976). The perforated pipe intake design for Lake Rousseau could be modified for use in any of the alternative source waters. This design allows low approach velocities as recommended and allows organisms to avoid the intake by swimming in any direction except directly into the inlet holes. Problems may be encountered with this design due to slime, algae, or weed fouling. Proposed backwash will help overcome this problem.

This design could greatly mitigate entrainment if the intake pipes are placed at the depth of the least productive waters. Studies are currently underway to identify the waters of lowest biological value in Lake Rousseau for this purpose.

If a pump platform is used with the perforated pipe intake, care should be taken to withdraw water from a point away from the base of the platform. The platform itself would act as habitat and protection for eggs and larvae of freshwater fish. If the intake is away from the platform, these organisms can be avoided.

Whatever the surface source, many commercially, recreationally, and ecologically important planktonic forms may be entrained and subjected to thermal and mechanical stress within the power plant (Florida Power Corporation, n.d.; Maturo, et al., 1974). Present technology could not prevent this entrainment in any manner which would be economically feasible. Table 9.4-15 gives a summary assessment of alternative water sources. Figure 9.4-2 summarizes the source and intake alternatives considered in this section. An intake placed on the existing discharge canal would reduce the impacts of cooling water withdrawal. Near the

Table 9.4-15 Environmental Assessment of Alternative Water Sources

Water Source	Advantages	Disadvantages
Gulf of Mexico through existing canals	1. Lower costs 2. No consumptive use of fresh water 3. If water is withdrawn from existing discharge canal no "new" water would be entrained.	1. Entrainment of important species 2. Impingement of important species (for once-through or PSM) 3. If cooling towers are used salinity contributes to technical problems and larger volume of water needed than fresh sources
Withlacoochee Reach of Cross Florida Barge Canal	1. Systems altered would be of lower value 2. No consumptive use of fresh water	1. Uncertainty of future plans for the area 2. If cooling towers are used a lower volume of water will be needed than for freshwater sources but technical problems may arise
Crystal River	1. Water of lower salinity than above sources	1. Consumptive use of fresh water 2. Entrainment of important species 3. Requires alteration of wetlands 4. Percentage of water to be used is higher than for Lake Rousseau
Lake Rousseau	1. Entrainment may be reduced by placing intake in waters of low biological productivity 2. Percentage of water used is lower than at Crystal River 3. May improve circulation in southwestern arm of the lake 4. Dissolved solids lower than for Crystal River or well fields would mean less water required for cooling towers	1. Consumptive use of fresh water 2. Potential for fouling problems from Asiatic Clam, Corbicula.
Well Fields	1. No entrainment or impingement	1. Potential for saltwater intrusion not clear 2. Water availability not clear

Source: Environmental Science and Engineering, Inc., 1978.

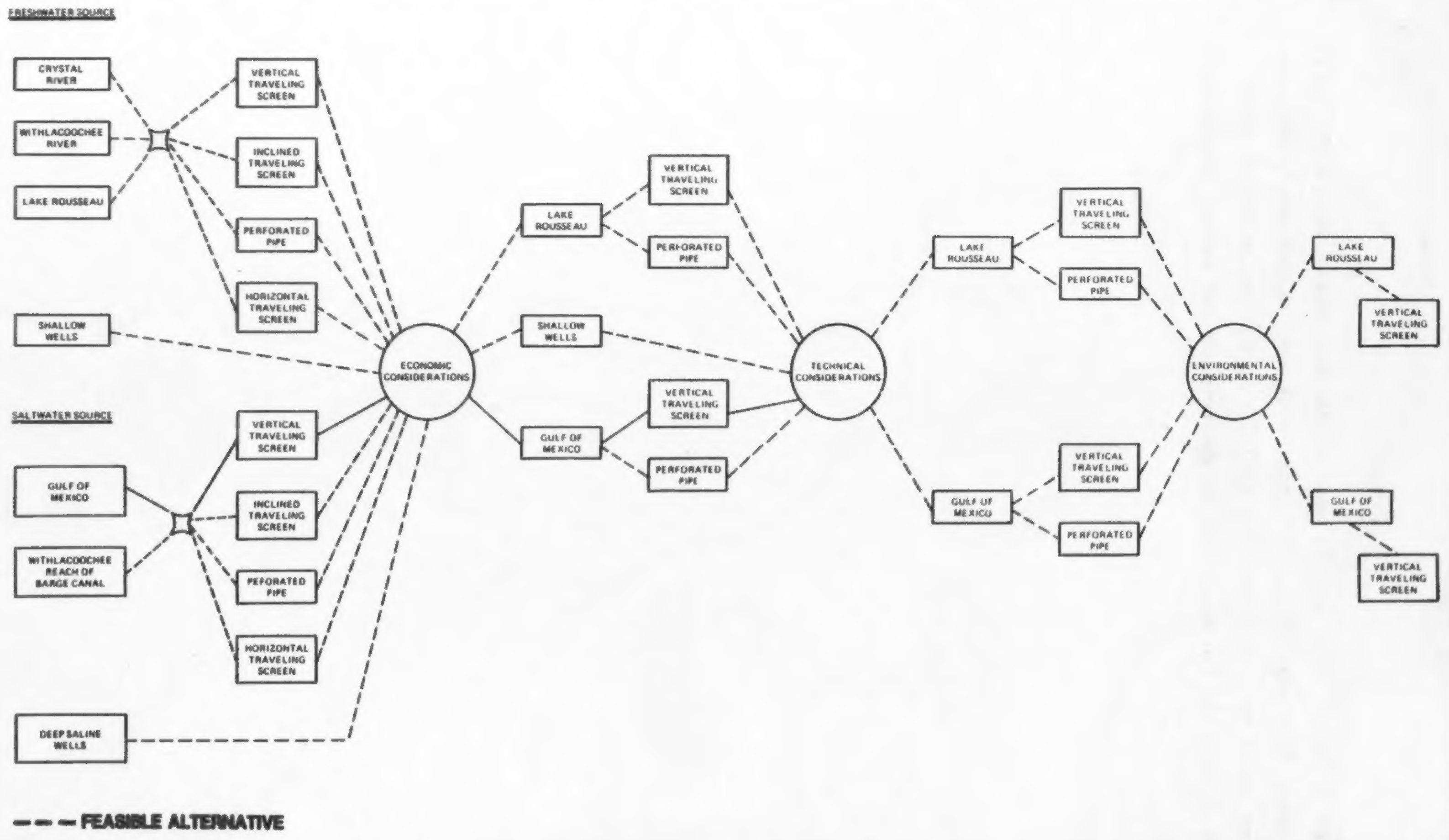
FRESHWATER SOURCE
CRYSTAL RIVER
WITHLACOOCHEE RIVER
LAKE ROUSSEAU
SHALLOW WELLS
SALTWATER SOURCE
GULF OF MEXICO
WITHLACOOCHEE REACH OF BARGE CANAL
DEEP SALINE WELLS
VERTICAL TRAVELING SCREEN
INCLINED TRAVELING SCREEN
PERFORATED PIPE
HORIZONTAL TRAVELING SCREEN
VERTICAL TRAVELING SCREEN
INCLINED TRAVELING SCREEN
PEFORATED PIPE
HORIZONTAL TRAVELING SCREEN
ECONOMIC CONSIDERATIONS
LAKE ROUSSEAU
SHALLOW WELLS
GULF OF MEXICO
VERTICAL TRAVELING SCREEN
PERFORATED PIPE
VERTICAL TRAVELING SCREEN
PERFORATED PIPE
TECHNICAL CONSIDERATIONS
LAKE ROUSSEAU
GULF OF MEXICO
VERTICAL TRAVELING SCREEN
PERFORATED PIPE
VERTICAL TRAVELING SCREEN
PERFORATED PIPE
ENVIRONMENTAL CONSIDERATIONS
LAKE ROUSSEAU
VERTICAL TRAVELING SCREEN
GULF OF MEXICO
VERTICAL TRAVELING SCREEN
– – – FEASIBLE ALTERNATIVE

Figure 9.4-2

SUMMARY DIAGRAM OF WATER SOURCE AND INTAKE ALTERNATIVES

SOURCE: Environmental Science and Engineering, Inc., 1978

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

discharge of Units 1, 2, and 3, most planktonic organisms in the water have already been entrained. If this water were withdrawn, fewer new organisms would be entrained. In addition, existing currents in the canal could be used to sweep the intake screens and reduce impingement.

9.5 COOLING SYSTEM ALTERNATIVES

9.5.1 OBJECTIVES

The general objective of this section is to examine alternative systems for removing waste heat from steam-generating electrical power plants. It is not possible to use all the heat energy transferred from the fuel source to steam in the generation of electrical energy, and it becomes necessary to remove this excess heat energy from the plant site on a continuous and operational basis. Waste heat is rejected from a plant site via cooling water from which it can be dissipated through circulation and evaporation. Several different circulation and evaporation systems for dissipating waste heat are in operation at power plants throughout the country. The specific objective of this section is to provide a basis for comparison of cooling system alternatives for the proposed new units of the Crystal River site. The bases for comparison are technical, economic, and environmental criteria.

9.5.2 EVALUATION CRITERIA

The following criteria were used for evaluation of heat dissipation systems:

1. The heat rejection system should be able to reject waste heat from two coal-fired generating units of 600 to 660 Mw net capacity. At peak loading rates, heat rejection would be approximately 8.316×10^8 kilocalories ($3,300 \times 10^6$ Btu) per hour.
2. The heat rejection system should allow operation of the units at maximum design capacity for 99 percent of the observed summer ambient conditions.
3. The heat rejection system should comply with Federal and State regulations.

9.5.3 ALTERNATIVES CONSIDERED

Analysis of alternative cooling systems was conducted on the basis of technical, economic, and environmental considerations. General acceptance of the technology by the utility industry in the United States and Florida was also a consideration. Cooling systems considered were:

1. Once-through cooling;
2. Mechanical draft wet cooling towers;
3. Natural draft wet cooling towers;
4. Power spray modules; and
5. Dry and wet-dry cooling towers.

ONCE-THROUGH COOLING SYSTEMS

Once-through cooling was considered for the proposed facility because this method is used predominately by Florida utilities and is used presently by the existing units at the proposed site.

Once-through cooling systems circulate water from a source through the plant to remove waste heat and then discharge the heated water back to the source. The existing once-through system at the Crystal River site serves three existing power generating units with total combined capacities of 1,752 Mw (Kemp, 1977). Table 9.5-1 lists the Crystal River site among power plants in the United States utilizing cooling water canals. Other types of once-through cooling systems such as man-made ponds or lakes were considered.

Cooling ponds continuously circulate power plant cooling water through a large lake or pond. The proposed facilities would require a cooling pond of at least 98 hectares (1,300 acres). This estimate is derived from the requirement of approximately .4 hectares (1 acre) cooling pond area per megawatt. As a consequence, large areas of natural habitat could be destroyed. Florida Power Corporation does not control sufficient land area suitable for the pond.

Table 9.5-1 Some Major Coastal and Estuarine Power Plants in the United States Utilizing Cooling Water Canal Systems (from Kemp, 1977)

Name of Plant	Location	Cooling Water Flow m^3/min	Length of Canals, km Intake	Length of Canals, km Discharge
Pilgrim[c]	Cape Cod Bay, Ma.	1,223	---	0.4
Brayton Point[c]	Naragansett Bay, Ma.	2,297	---	0.4
Millsonte[d]	Niantic Bay, Conn.	3,545	---	0.5
Conn. Yankee[e]	Conn. R., Conn.	1,505	---	1.9
Oyster Creek[c]	Barnegat Bay, N.J.	1,632	1.1(2.4)[a]	1.0(2.4)[a]
Indian River[c]	Indian R., Del.	570	0.2	3.0
Peach Bottom[f]	Susquehanna R., Pa.	5,690	---	1.4
Chalk Point[c]	Patuxet R., Md.	1,894	0.5	2.4
Morgantown[g]	Potomac R., Md.	4,250[b]	---	0.6
Douglas Pt.[g]	Potomac R., Md.	2,400[b]	0.3	---
Yorktown[h]	York R., Va.	2,700[b]	0.3	0.5
Surry[c]	James R., Va.	6,360	3.2	0.8
Chesterfield[i]	James R., Va.	2,776	---	0.5(6.0)[a]
Cape Fear[c]	Cape Fear, N.C.	1,017	---	---

Table 9.5-1 Some Major Coastal and Estuarine Power Plants in the United States Utilizing Cooling Water Canal Systems (from Kemp, 1977) (Continued, page 2 of 2)

Name of Plant	Location	Cooling Water Flow m^3/min	Length of Canals, km	
			Intake	Discharge
Brunswick[j]	Cape Fear, N.C.	6,800	5.2	9.7
Turkey Point[k]	Biscayne Bay, Fla.	2,176	0.5	6.6
Anclote[l]	Tarpon Springs, Fla.	2,720	1.0	1.2
Crystal River[m]	Crystal River, Fla.	2,414	5.0	2.0
Bartow[n]	St. Petersburg, Fla.	1,476	0.3	0.3
P.H. Robinson[c]	Galveston Bay, Tex.	4,226[b]	2.5	2.5
Cedar Bayou[o]	Galveston Bay, Tex.	2,550[b]	---	9.8

[a] Numbers in parentheses indicate tidal creeks which are serving as canals.
[b] Estimates based on megawatt rating and condenser temperature rise.
[c] Clark and Brownell (1973); [d] AEC (1973b); [e] AEC (1973a); [f] AEC (1972c); [g] W. Boynton (personal comm.); [h] White, et al. (1976); [i] Koss, et al. (1974); [j] AEC (1974); [k] Nugent (1970), prior to the construction of Unit 3; [l] Kemp (1976); [m] this study; [n] Blake, et al. (1976); [o] Gilmore, et al. (1975).

The Southwest Florida Water Management District (SWFWMD) has suggested that power plants examine once-through cooling with estuarine water coupled with a desalinization process. This option would allow power plants to produce fresh water rather than consume it (SWFWMD, 1977). Such an option would require further study before economic and technical implications could be evaluated. Table 9.5-2 presents data (Kemp, 1977) for existing desalinization plants throughout the world which provide some information regarding the energetics of present systems.

Once-through cooling alternatives for the proposed units would utilize the existing intake and discharge canals to the greatest extent possible. However, the existing canal cross sectional area must be modified to handle the greater flow volumes. Each new power unit will require 1,820 cubic meters (480,000 gallons) per minute. The main condenser system requires 1,740 cubic meters (460,000 gallons) per minute, and the auxiliary cooling system requires 76 cubic meters (20,000 gallons) per minute. Consequently, the existing flow of 5,220 cubic meters (1,380,000 gallons) per minute will be increased to 8,680 cubic meters (2,294,000 gallons) per minute. Deepening of the intake canal to 5.5 meters (18 feet) below mean low water and of the discharge canal to 4.6 meters (15 feet) below mean low water would be required. These modifications will maintain the existing hydraulic characteristics of Units 1, 2, and 3. Intake canal flow velocities would be increased from 0.40 to 0.49 meters (1.3 to 1.6 feet) per second on the ebb tide. Flood tide velocities would be higher. To reduce intake velocities would be costly. Velocities in the discharge canal would be 0.76 meters (2.5 feet) per second on the ebb tide.

The Units 4 and 5 will have a temperature rise of 8.1°C (14.5°F) at an intake ambient temperature of 30.6°C (87°F). This temperature rise is the same as the combined discharge of Units 1, 2, and 3. However, with Units 4 and 5 operating at maximum power, the volume of water and the amount of heat discharged would be increased by 70 percent. This larger

Table 9.5-2 Summary of Desalinization Data for Selected, Cost-Effective Plants (from Kemp, 1977)

Plant Location	Method[a]	Capacity m^3/day	Annual Cost Minus Direct Energy[b]		Electric and Fuel Costs[c] kcal CE/m^3	Salinity, ppm[d]		Free Energy[e] Delta G kcal/m^3	Ratio, Annual Cost/ Free Energy
			\$/m^3	kcal CE/m^3		In	Out		
Aruba[f]	ST	9,000	.56	13,300	12,260	35,000	5	5,374	4.8
Isreal[f]	VF	908	.43	9,630	9,410	41,500	500	3,142	6.1
Iran[f]	MFD	1,390	.51	9,080	11,170	35,000	25	4,395	4.6
Kuwait[f]	ST	4,500	.43	8,340	9,410	45,000	50	5,302	3.3
Kuwait[f]	MFD	9,000	.43	8,170	9,410	45,000	50	5,302	3.3
#44-49,20-24[g]	MFD	1,045	.29	4,960	6,350	35,000	50	3,971	2.8
Saudi Arabia[h]	MFD	38,000	.14	2,180	3,060	35,000	50	3,971	1.3
Israel[i]	MFD-DP	400,000	.13	2,080	2,850	35,000	50	3,971	1.2
Key West[j]	MFD	10,300	.22	5,680	4,820	35,000	50	3,971	2.6
Tijuana[k]	MFD-DP	28,400	.17	3,890	3,720	35,000	50	3,971	1.9
Cuba	MFD	4,740	.28	7,220	6,130	33,600	50	3,919	3.4
Virgin Is.[m]	MFD	8,500	.20	4,060	4,380	35,000	50	3,971	2.1
Mean			.32	6,549	6,914			4,271	3.1

Table 9.5-2 Summary of Desalinization Data for Selected, Cost-Effective Plants (from Kemp, 1977) (Continued, page 2 of 2)

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[a] Abbreviations for methods are: ST=submerged tube distillation; VF=vacuum freeze; MFD=multi-flash distillation; MFD-DP=multi-flash distillation combined with steam electric power plant in dual purpose unit.

[b] Annual costs are given in U.S. dollars of year reported (1959-1969), and energy costs are given in coal equivalents for the given year, estimated using kcal/$ ratios for particular country as reported by Darmstadter, *et al*. (1971) and Kylstra (1974).

[c] Electricity and fuel costs taken at 6 percent and 7 percent of total cost, respectively (United Nations, 1964). Coal equivalent energy per unit price taken from Zucchetto (1975a).

[d] Salinity values for most plants tabulated were reported in the literature. However, some are estimated based on knowledge that feedwater is ocean quality and on typical performance reported for particular method.

[e] Free energy of chemical potential is calculated from $=nRT \ln (C_1/C_2)M_s$, where n=moles salt, R=gas constant, T=absolute temperature, M_s=mass of removed, C_1=input salinity, C_2=output salinity.

[f] United Nations (1964) $G = (\frac{\text{mole}}{35\ \text{g}})(1.99\text{x}10^{-3}\ \text{kcal/deg·mole})(305°)(10^6\ \text{g/m}^3)(\frac{\text{Cl}}{1{,}000(C_1-C_2)})\ \ln(C_1/C_2)$

[g] Location of plants not given (United Nations, 1969). A composite energy/$ ratio is used assuming all are located in Caribbean and Near East.

[h] Siefert, *et al*. (1973).

[i] Clawson, *et al*. (1969).

[j] Wright (1969).

[k] Steinbruchel and Beagle (1968).

[l] Jebens and Dykstra (1965).

[m] Foster (1969).

Source: Kemp, 1977.

discharge will increase the possibility that heated water will be recirculated into the station condensers under certain environmental conditions. It was conservatively assumed that a .56°C (1°F) rise at the station inlet would occur on an annual average. The cost analysis demonstrated that it is not economically feasible to build a dike to prevent circulation. The annual fuel costs due to a delta .56°C (1°F) temperature at the station intake is $265,000. The annualized construction cost of a diversion dike to prevent recirculation is $2,176,000 (Black and Veatch, 1976).

The optimum system parameters for a once-through cooling system based on technical and economical considerations were determined as presented in Table 9.5-3.

Consideration of once-through cooling as an alternative required examination of three alternative intake and discharge canal layouts; one for each of the three possible plant locations discussed in Section 9.2.

The layout for Location 1 is shown in Figure 9.2-10 (Black and Veatch, 1976). An intake canal depth of 5.5 meters (18 feet) below mean low water is required to maintain a flow velocity of 0.5 meters (1.6 feet) per second. This flow will be accomplished after deepening the existing canal for deeper draft.

The existing discharge canal would have to be dredged an additional 1.5 meters (5 feet) to a depth of 4.6 meters (15 feet) below mean low water level. Dredging would start at the point of discharge of Units 4 and 5 circulating water and proceed westward approximately 1,280 meters (4,200 feet). In addition, a spur to the existing canal would be extended northeast approximately 381 meters (1,250 feet), terminating at the new plant. The discharge canal velocity would be 0.76 meters (2.5 feet) per second at ebb tide with all units in operation.

Table 9.5-3 Circulating Water System Parameter Values Used for Once-Through System Evaluation

Item	Parameter Value	
Flow Rate	1,741 m^3/minute	460 gpm
	2,506,000 m^3/day	662 mgd
Condenser Surface Area	28,000 m^2	300,000 sq. ft.
Peak Condenser Pressure	7.24 cm	2.85 in Hg, absolute
Condenser		
Tube length	12.2 meters	40 feet
Tube diameter	2.54 centimeters	1.0 inch
Tube material		90-10 copper-nickel
Tube gauge		18
Water velocity	2.44 meters/second	8.0 feet/second
Piping		
Material		Fiberglass reinforced plastic
Diameter	244 to 305 centimeters	96 to 120 inches
Number		2
Water velocity	2.44 to 3.05 meters/second	8 to 10 feet/second
Intake System		
Pump type		Vertical
Capacity, percentage each		25
Number		4
Screen type		Traveling

Source: Black & Veatch, 1976.

The intake structure would be located flush with the north bank of the existing intake canal. Units 4 and 5 would require 900 meters (3,000 feet) and 1,100 meters (3,600 feet), respectively, of 108-inch fiberglass reinforced pipe. Piping to each unit would be placed in a common trench at a depth of 0.9 to 1.5 meters (3 to 5 feet) below grade. Auxiliary cooling system heat exchangers would be supplied via the circulating water system. Estimated flow is 76 cubic meters (20,000 gallons) per minute. Auxiliary cooling water would be discharged into the main cooling system discharge canal.

The once-through cooling system for Location 2 (Figure 9.2-11) is identical in concept to the once-through system at existing Units 1, 2, and 3. Some features are unique to Location 2 and differ significantly from Location 1. The point at which the heated circulating water enters the discharge canal is about 240 meters (800 feet) east of Location 1. Therefore, an additional 240 meters (800 feet) of dredging for a total of 1,500 meters (5,000 feet) would be required. The intake canal will require dredging to 5.5 meters (18 feet) below mean low water. The circulating water piping to and from the unit condenser would consist of two 108-inch fiberglass reinforced plastic pipes. Each pipe would be approximately 70 meters (1,200 feet) in length.

The once-through cooling system for Location 3, shown in Figure 9.2-12, is identical in concept to the once-through system at Location 1. The point at which the heated circulating water enters is at the extreme east end of the existing discharge canal, which will necessitate dredging the entire discharge canal to 4.6 meters (15 feet) below mean low water level. The dredging would result in an increase in dredging of 980 meters (3,200 feet) as compared to dredging in Location 1. The total dredging required will be 2,300 meters (7,400 feet). The circulating water piping to and from the unit condensers would consist of two 108-inch fiberglass reinforced plastic pipes. Each pipe would be approximately 600 meters (2,000 feet) in length for Unit 1 and 850 meters (2,800 feet) in length for Unit 2.

NATURAL DRAFT COOLING TOWERS

Natural draft cooling towers use evaporative cooling. The air flow through a natural draft cooling tower is provided by the density difference between atmospheric air and the air inside the tower, which has been warmed by the hot water from the plant condensers. In order to maximize this buoyancy differential, natural draft cooling towers presently are designed to be hyperbolic in shape and to have high exhaust heights.

Natural draft cooling towers are gaining acceptance rapidly in the power industries in areas of high humidity, primarily because they offer an economic advantage over other alternatives which have substantial energy costs, such as mechanical draft cooling towers. At the present time there are no natural draft cooling towers in operation in Florida.

One natural draft cooling tower per unit would be used. The tower would be designed to dissipate 8.316×10^8 kilocalories (3.3×10^9 Btu) per hour with a range of 12°C (22°F), assuming 26°C (79°F) wet bulb and an approach of 8°C (15°F). Under these design conditions, the water which is supplied to the unit condensers would be 34°C (94°F). The cooling tower would be approximately 120 meters (400 feet) high and 100 meters (325 feet) in diameter at the base.

A wet, natural draft cooling tower incorporates direct contact between the cooling medium (air) and the circulating water. Heat is transferred primarily through evaporation of the circulating water. The draft through a natural-draft tower depends upon three parameters: (1) the density difference between the ambient air and the warm, moist air in the tower; (2) the pressure difference due to the chimney height; and (3) the induced draft due to the wind velocity. Two types of flow, crossflow and counterflow, are utilized in natural-draft towers. A crossflow tower incorporates a horizontal air flow through the fill and the falling water, while the counterflow tower incorporates a vertical air flow through the fill. The saltwater system would be operated at between 2.0 and 1.3 cycles of concentration, while the freshwater system would be operated at about 6 cycles of concentration. Water treatment measures for the control of corrosion, scale, and biological fouling have not been specified at this time.

The major components of a natural draft cooling tower system include the turbine generator, the condenser, the natural draft cooling tower, sources of intake water, intake structure, circulatory water piping, and an auxiliary cooling system. The information presented is for one unit unless otherwise noted.

A study was performed to determine the optimum condenser size for a saltwater makeup system. The results, based upon current project economic criteria, determined that the optimum condenser is a two-pass arrangement with a surface area of approximately 120,000 square meters (400,000 square feet). With this alternative, the temperature rise would be 12°C (22°F) and the pressure would be 8.99 centimeters (3.54 inches) Hg absolute under peak loading conditions. A 90-10 copper-nickel tubing is expected to perform satisfactorily with salt water at approximately 50,000 ppm salt of concentration or fresh water. The circulatory water flow rate would be approximately 1.150 cubic meters (304,000 gallons) per minute.

The circulating water flow rate for the natural draft cooling tower heat dissipation system would be 1,150 cubic meters (304,000 gallons) per minute requiring one supply pipe and one return pipe, each consisting of a 108-inch fiberglass reinforced plastic pipe. Each pipe would be placed in a trench at a depth of 1 to 1.5 meters (3 to 5 feet) below grade.

The cooling tower makeup piping for salt water would be approximately 120 centimeters (48 inches) in diameter to transport 45 to 95 cubic meters (12,000 to 25,000 gallons) per minute from a new intake structure on the existing discharge canal to the cooling tower basin. The blowdown piping would be approximately 137 centimeters (54 inches) in diameter and would transport approximately 23 to 76 cubic meters (6,000 to 20,000 gallons) per minute from the tower basin to the discharge canal. The cooling tower piping system for fresh water would be similar to that for the saltwater alternative, but because freshwater needs are less, the piping could be somewhat smaller.

An auxiliary once-through cooling system or closed cycle system would be used for auxiliary equipment cooling. The once-through alternative, which would be used to supplement one saltwater cooling tower alternative, would use water from the existing intake canal and discharge into the cooling tower. For either a freshwater and saltwater tower, the auxiliary cooling water system could be a part of the closed-cycle cooling system. The estimated flow for auxiliary cooling would be approximately 76 cubic meters (20,000 gallons) per minute.

The natural draft cooling tower heat dissipation system would require approximately 5 to 12 cubic meters (12,000 to 25,000 gallons) per minute of saltwater makeup per unit to replace water lost in the system due to evaporation and blowdown. The freshwater towers would require approximately 50 cubic meters (13,700 gallons) per minute for makeup and auxiliary cooling for both units.

Conceptual studies were conducted in 1976 to assess alternative locations for expanding generation facilities at the Crystal River site using natural draft cooling towers. See Figures 9.2-3, 9.2-4, 9.2-5, and 9.2-6 for presentation of these layouts.

MECHANICAL DRAFT WET COOLING TOWERS

Mechanical draft wet cooling tower systems utilize evaporative cooling to provide the necessary condenser cooling for the steam generator. In these towers, fans provide the air flow for the interaction of the air and water. As far as cooling tower systems are concerned, mechanical draft towers have been the major method for providing closed-cycle cooling in the utility industry. In Florida, mechanical draft cooling tower systems have mainly been utilized on smaller facilities (30-150 Mw). At the present time, one mechanical draft cooling tower of approximately the same size as the proposed units is in operation in Florida. For Units 4 and 5, it is assumed that the condenser size, circulating water flow rate, and tower approach will be the same as the natural draft selection. The only difference would be the tower design and circulating water piping.

Two mechanical draft cooling towers per unit would be necessary. The towers would be designed to dissipate 8.316×10^8 kilocalories (3.3×10^9 Btu) per hour per unit with a range of 12°C (21°F), 26°C (79°F) wet bulb, and an approach of 8°C (15°F). Under the above conditions, the temperature of the water to the condensers would be 34°C (94°F). The saltwater tower would operate at between 2.0 and 1.3 cycles of concentration with a makeup rate to offset evaporation and blowdown of between 45 and 95 cubic meters (25,000 gallons) per minute respectively. A freshwater tower would operate with six cycles of concentration and 440 liters per second (6,900 gallons per minute) makeup per tower. Each tower would be approximately 68.6 meters (225 feet) in diameter and 18 meters (60 feet) high.

The mechanisms (evaporation and convection) whereby heat exchange takes place in a mechanical draft cooling tower are identical to a natural draft tower. The mechanical-draft cooling tower incorporates the use of fans to provide the flow through the cooling tower and to eliminate the need for the great height of the natural-draft towers. The air flow rate is controlled to satisfy the cooling tower design requirements. Present mechanical-draft units are typically 15 to 30 meters (49 to 98 feet) high. Future towers will be built to greater heights. The mechanical systems available are forced-draft and induced-draft counter/crossflow types.

Multifan freshwater mechanical draft cooling towers have been used extensively throughout the United States for power plant heat dissipation systems. There are two primary types of mechanical draft tower arrangements; the in-line fan and the clustered fan arrangement.

The in-line fan arrangement is commonly referred to as a conventional cooling tower and has been used in numerous applications. However, the clustered fan arrangement offers distinct advantages over the conventional cooling tower. These advantages are as follows:

1. A consolidated plume which minimizes the effects of fog and drift. This could be important at Crystal River if the tower were to operate with saltwater and if drift is considered troublesome.
2. Improvement in site arrangement which results in reduction in circulating water piping lengths and system head losses.
3. A more predictable performance because the effects of recirculation are greatly reduced.

The clustered fan arrangement generally is about 20 to 30 percent higher in initial capital cost than in-line arrangement. However, savings in piping length (because the towers can be located closer to the central plant complex and closer together) make the total system cost about equal. Therefore, because of its inherent advantages for the Crystal River site, only the clustered fan arrangement will be considered in this analysis.

The basic components of mechanical draft cooling towers are similar to the previously discussed natural draft towers. Two exceptions are the tower framework and the fans.

The tower framework in a mechanical draft cooling tower consists of columns, diagonal braces, and a system of longitudinal and transverse ties. The fans, which provide air movement in mechanical towers, can be located at either the top or bottom of the tower. Fan diameter in large modern towers may be 26 meters (86 feet). The blades are made of resin-coated fiberglass or coated aluminum to provide a lightweight corrosion-resistant mechanism.

Layouts for mechanical draft cooling towers are presented in Figures 9.2-7, 9.2-8, and 9.2-9 for locations 1, 2, and 3.

DRY AND WET-DRY COOLING TOWERS

The dry systems are based upon indirect contact between the air and the hot water, and heat transfer takes place through convection and conduction. Dry (non-evaporative) cooling towers are installed to circumvent problems of vapor plumes associated with mechanical draft wet cooling towers or to avoid high water consumption associated with large natural draft hyperbolic cooling towers. However, the impairment of condenser pressure for summer ambient conditions results in year-round penalties in plant performance, which makes dry cooling systems economically difficult to justify (Klanian and Noyes, 1973). Dry type cooling tower systems not only are significantly higher than wet tower systems in capital costs, but their incremental generation cost is higher because of heat rate and replacement capability penalties associated with high condenser pressure.

Wet/dry tower systems make use of both direct and indirect contact between the air and the water, and the heat transfer takes place through evaporation, convection, and conduction. A wet/dry system can utilize a combination wet/dry mechanical draft cooling tower, or it can employ a conventional wet tower and a separate, conventional dry tower. In systems employing separate wet and dry towers, the dry tower operates year-round and does its greatest work in winter, while the wet tower operates only during warmer periods.

Wet/dry cooling tower systems are designed to achieve one of the following objectives:

1. Diminish visible water-vapor plumes,
2. Obtain colder fluid temperature which approaches ambient wet bulb, or
3. Conserve makeup water, as compared to a 100 percent wet tower.

Wet/dry systems are generally more expensive than wet systems due to high capital and operating costs. Incremental generation costs for wet/dry systems are usually intermediate between lower-cost wet systems and higher-cost dry systems. No dry or wet/dry cooling systems are being used by electric utilities in Florida at this time.

POWER SPRAY MODULES

Heat dissipation by spray cooling is an alternative that may be used in cases where sufficient land is not available for cooling ponds, or where increased heat dissipation through existing ponds or canals is desired. The power spray module system considered for the proposed Crystal River site consisted of installing power spray modules in the discharge canal of the existing once-through cooling system. Increased cooling is achieved by positioning power spray modules (PSM) in the discharge canal to cool the water before it reaches the Gulf. Prior to reaching the point of discharge (POD), sufficient dilution water is added to reduce the discharge temperature in order to meet Florida effluent standards.

The PSM discussed in this section is manufactured by Ceramic Cooling Tower Company and is in operation at several installations including the

Commonwealth Edison Company Quad-Cities Nuclear Station. Thermal performance tests conducted during the summer of 1975 show the system to be operating at 100 percent performance.

Spray module systems similar to the PSM system are also in operation at various installations. However, for purposes of this study, the PSM is considered to be representative of the various systems presently being utilized.

It is not economically feasible to provide sufficient cooling with a PSM system alone to meet the State of Florida thermal effluent standards; i.e., 1.1°C (2.0°F) in the summer and 2.2°C (4.0°F) in the winter. It would require 7,300 meters (24,000 feet) of canal to accomplish this degree of cooling. The temperature of the discharge water can be reduced to within 3.3°C (6.0°F) of summer ambient with sprays, and dilution water can be added to accomplish another 1.1°C (2.0°F) of cooling. Thus the discharge temperature would be reduced to within 2.2°C (4.0°F) and 4.4°C (8.0°F) of ambient in the summer and winter, respectively. These temperatures exceed the State of Florida effluent standards; however, to achieve any further cooling would require substantial additional investment and operating costs which would make this arrangement so costly that it would not be feasible to consider.

To use power spray modules at Location 1 (see Section 9.2), the existing inlet canal would be required to accommodate a dilution flow rate of one million gpm. Therefore, it would be necessary to widen the existing intake canal approximately 23 meters (75 feet) in order to maintain a canal velocity of .49 meters (1.6 feet) per second based on 5.5 meters (18 feet) of depth. Another approach would be to construct a canal running parallel on the north side of the existing intake canal. This method would produce unpredictable dilution temperatures because of the potential of recirculating heated discharge water. Therefore, only widening of the existing intake is given consideration for cost analysis.

The discharge canal would be required to accommodate the four pass PSM system and would have to be widened to at least 49 meters (160 feet) and extended 1,040 meters (3,400 feet) into the Gulf. In order to reduce the temperature of the effluent from the new units to within 2.2°C (4°F) and 4.4°C (8°F) of ambient in the summer and winter, respectively, 176 PSM units are required. If the modules are placed four abreast, a channel length of 2,150 meters (7,040 feet) will be utilized by the spray system [the entire discharge canal length plus an addition 1,040 meters (3,400 feet)]. Each module would have a 56-kilowatt (75-horsepower) electric motor for a total energy requirement of 9,840 kilowatts (13,200 horsepower).

A dilution canal, running north from the existing intake canal to the discharge canal and having dimensions of 38 meters (125 feet) wide, 3 meters (10 feet) deep, and 1,010 meters (3,300 feet) long would be required. The canal would supply dilution water to three dilution pumps which would be located on the south bank of the discharge canal. Each dilution pump would be rated at 1,260 cubic meters (334,000 gallons) per minute.

The PSM system at Location 1 would consist of a series of self-contained spray modules spanning the width and length of the channel. Each unit would be made up of a circulating pump and a group of four, deflector-type spray nozzles spaced 12 meters (40 feet) on centers. The entire unit would be supported by a series of floats and moored in place in the channel. Each module would operate independently and would require a 56-kilowatt (75-horsepower) motor drive. The modules are placed side-by-side in the channel. For Crystal River, the modules would be placed four abreast in the channel (four-pass).

For Location 2, the sprays would begin about 240 meters (800 feet) further east and the dilution canal will likewise be placed 240 meters (800 feet) to the east. All other features remain essentially unchanged.

At Location 3, it would be desirable to start the sprays as far east in the discharge canal as possible. However, in order to prevent the drift from reaching the substation, it would be necessary to begin the sprays 120 meters (400 feet) west of the substation. As a result, the spray system would start 670 meters (2,200 feet) farther east than was possible for location 1. Hence, a significant amount of dredging would be saved as compared to Location 1.

9.5.4 COMPARATIVE ANALYSIS OF ALTERNATIVE COOLING SYSTEMS

ECONOMIC CONSIDERATIONS

Cost comparisons were made for all alternatives considered. General incremental cost data (Figure 9.5-1) for wet towers, wet/dry towers, and dry towers indicated capital costs for dry and wet/dry towers to be significantly higher than those for wet towers. Because of these significant differences, wet/dry and dry towers costs were not pursued further. Site-specific costs were developed for all other alternatives considered.

Cost comparisons were developed for saltwater cooling at Alternative Site Locations 1, 2, and 3 in 1976 (Black and Veatch). In 1977, as conceptual planning for the facility progressed, freshwater and saltwater cost comparisons were developed for Location 1c (Black and Veatch). In this document other costs figures are also presented for comparison. These costs are from Kemp (1977) and U.S. EPA (1973).

Capital and annual cost summaries developed by design engineers in 1976 for four types of cooling alternatives are given in Tables 9.5-4 through 9.5-9 for Site Locations 1, 2, and 3 and in Tables 9.5-10 and 9.5-11 for Location 1c. These costs are per unit for each of the proposed Units 4 and 5. Maintenance costs are summarized in Table 9.5-12. Fuel costs for the natural draft and mechanical cooling towers are based on increases of unit heat rates by 5.3 kcal/kwh (21 Btu/kwh) and 7.6 kcal/kwh (30 Btu/kwh), respectively, over the saltwater systems.

The 1976 study showed similar costs for locations and alternatives. Rank according to capital and annual costs was the same for Locations 1, 2, and 3. The alternative of lowest cost was once-through cooling, while power spray modules were the most expensive. Saltwater towers were intermediate in costs. Maintenance costs were not included in these cost comparisons.

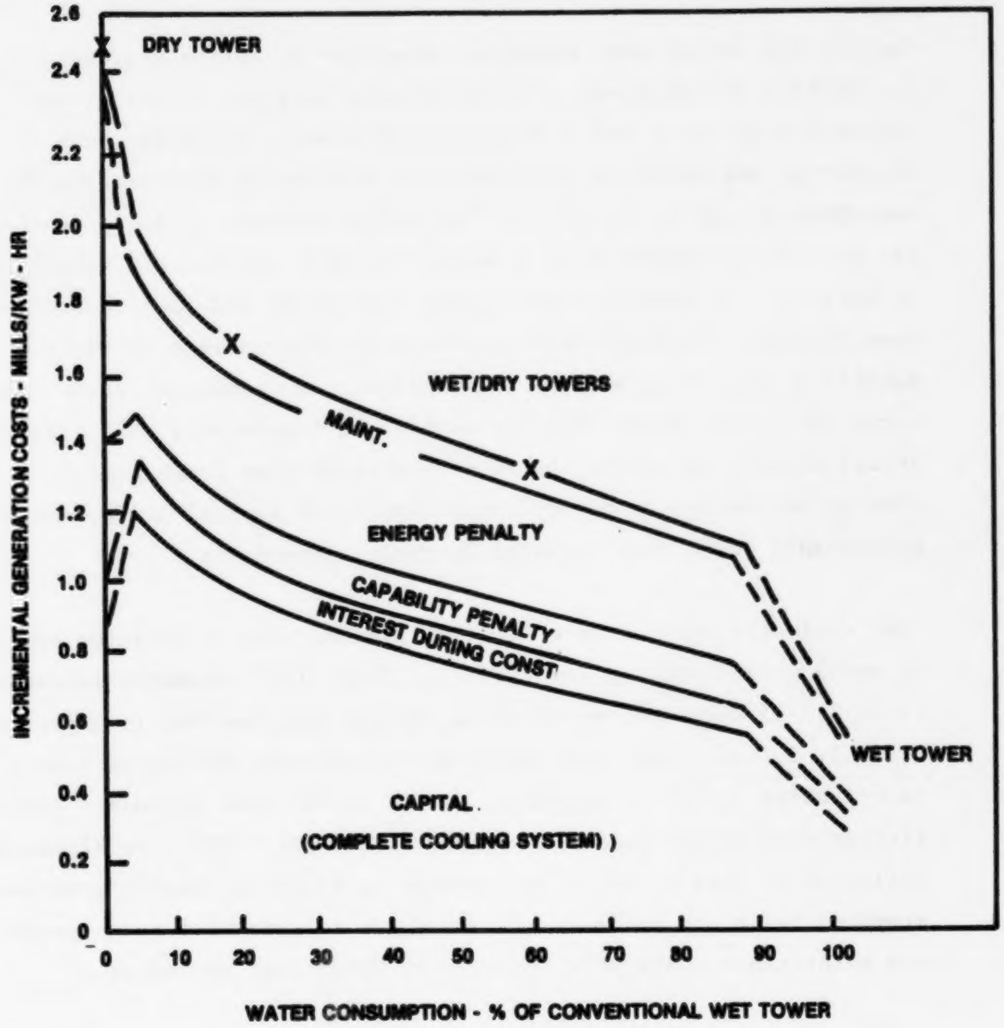

Figure 9.5-1

POWER INDUSTRY BASED ON INCREMENTAL COSTS OF VARIOUS TYPES OF COOLING TOWERS

SOURCE: Klanian and Noyes, 1973

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

Capital and annual cost summaries developed by design engineers in 1977 for cooling alternatives at proposed site Location lc are given in Tables 9.5-10 and 9.5-11. These tables present costs for both freshwater and saltwater cooling tower systems as well as data for once-through and spray/dilution saltwater systems. Costs presented are per unit for proposed Units 4 and 5. In both capital and annual costs at Location lc, once-through cooling was lowest and power spray modules were highest. Cooling tower options were intermediate in costs. Natural draft towers were more expensive than mechanical draft towers in terms of capital costs, but the mechanical towers were more expensive in annual costs. Saltwater towers were cheaper than freshwater towers, whether mechanical or natural draft (for both capital and annual costs). Maintenance costs were included in these comparisons.

Cost estimates for saltwater cooling alternatives at existing Units 1, 2, and 3 were listed by Kemp (1977). These cost estimates presented in Table 9.5-13 were for back-fitting cooling alternatives to existing Units 1, 2, and 3 and used existing once-through cooling as base. Back-fitting costs are generally two to three times optimized costs for fitting cooling systems to new plants (U.S. EPA, 1973), so higher costs reflected in Kemp's values as compared to Black and Veatch's values for proposed units are probably primarily due to retrofitting. Operation and maintenance costs were included in these cost estimates.

It is not the absolute magnitudes of the costs which are of primary interest, however (since estimates are not in constant dollars), it is the order of comparison when ranked according to lowest cost. Table 9.5-14 compares capital cost data by Black and Veatch and Kemp with another set of data by U.S. EPA (1973). The EPA data is offered as a basis of comparison of capital cost data for proposed power plants with typical values for new plants.

Table 9.5-4 Capital Cost Summary*
Alternative Cooling Systems, Location 1 (Per Unit)

Item	Mechanical Draft Tower	Natural Draft Tower	Spray/ Dilution System	Once-Through Cooling
Condenser	$ 4,000	$ 4,000	$ 3,000	$ 3,000
Intake System	936	936	4,000	2,000
Piping System	1,416	1,151	2,173	2,173
Cooling Tower	5,319	7,000	--	--
Pumping System	1,220	1,220	1,564	1,164
Spray System	--	--	3,960	--
Canal Work	--	--	3,862	968
Total Direct Costs	12,891	14,307	18,559	9,305
Differential Costs	3,586	5,002	9,254	Base

*All values presented in thousands of dollars (1977).

Source: Black and Veatch, 1976.

Table 9.5-5 Capital Cost Summary*
Alternative Cooling Systems, Location 2 (Per Unit)

Item	Mechanical Draft Tower	Natural Draft Tower	Spray/ Dilution System	Once-Through Cooling
Condenser	$ 4,000	$ 4,000	$ 3,000	$ 3,000
Intake System	936	936	4,000	2,000
Piping System	1,201	1,006	504	504
Cooling Tower	5,319	7,000	--	--
Pumping System	1,220	1,220	1,564	1,164
Spray System	--	--	3,906	--
Canal Work	--	--	3,463	442
Total Direct Costs	12,676	14,162	16,437	7,110
Differential Costs	5,566	7,052	9,327	Base

*All values presented in thousands of dollars.

Source: Black and Veatch, 1976.

Table 9.5-6 Capital Cost Summary*
Alternative Cooling Systems, Location 3 (Per Unit)

Item	Mechanical Draft Tower	Natural Draft Tower	Spray/ Dilution System	Once-Through Cooling
Condenser	$ 4,000	$ 4,000	$ 3,000	$3,000
Intake System	936	936	4,000	2,000
Piping System	983	698	1,436	1,436
Cooling Tower	5,319	7,000	—	--
Pumping System	1,220	1,220	1,564	1,164
Spray System	—	—	3,960	—
Canal Work	--	--	3,888	1,076
Total Direct Costs	12,458	13,854	17,848	8,676
Differential Costs	3,782	5,178	9,172	Base

*All values presented in thousands of dollars.

Source: Black and Veatch, 1976.

Table 9.5-7 Annual Cost Summary*
Alternative Cooling Systems, Location 1 (Per Unit)

Item	Mechanical Draft Tower	Natural Draft Tower	Spray/ Dilution System	Once-Through Cooling
Fuel†	$ 470	$ 326	Base	Base
Energy**	1,939	1,405	2,142	718
Demand Charges	404	313	444	149
Fixed Charges††	3,616	4,013	5,206	2,610
Total Annual Cost	6,429	6,057	7,792	3,477
Differential Annual Costs	2,952	2,580	4,315	Base

*All values presented in thousands of dollars.
†Represents lost efficiency in steam cycle.
**Represents energy required to operate cooling system.
††Fixed charges are based on capital costs that are escalated to 1981 and include indirect costs. These costs are as follows:

Total Direct Costs (from Table 9.5-3)	12,891	14,307	18,559	9,305
Escalation and Indirect Costs	8,379	9,300	12,063	6,048
Total Capital Costs	21,270	23,607	30,622	15,353

Source: Black and Veatch, 1976.

Table 9.5-8 Annual Cost Summary*
Alternative Cooling Systems, Location 2 (Per Unit)

Item	Mechanical Draft Tower	Natural Draft Tower	Spray/ Dilution System	Once-Through Cooling
Fuel†	$ 470	$ 326	Base	Base
Energy**	1,939	1,405	2,142	718
Demand Charges	404	313	444	149
Fixed Charges††	3,556	3,972	4,626	1,994
Total Annual Cost	6,369	6,016	7,212	2,861
Differential Annual Costs	3,508	3,155	4,351	Base

*All values presented in thousands of dollars.
†Represents lost efficiency in steam cycle.
**Represents energy required to operate cooling system.
††Fixed charges are based on capital costs that are escalated to 1981 and include indirect costs. These costs are as follows:

Total Direct Costs (from Table 9.5-4)	12,676	14,162	16,437	7,110
Escalation and Indirect Costs	8,239	9,205	10,719	4,622
Total Capital Costs	20,915	23,367	27,156	11,732

Source: Black and Veatch, 1976.

Table 9.5-9 Annual Cost Summary*
Alternative Cooling Systems, Location 3 (Per Unit)

Item	Mechanical Draft Tower	Natural Draft Tower	Spray/ Dilution System	Once-Through Cooling
Fuel†	$ 470	$ 326	Base	Base
Energy**	1,939	1,510	2,142	718
Demand Charges	404	313	444	149
Fixed Charges††	3,495	3,886	5,006	2,434
Total Annual Cost	6,308	6,035	7,592	3,301
Differential Annual Costs	3,007	2,734	4,291	Base

*All values presented in thousands of dollars.

†Represents lost efficiency in steam cycle.

**Represents energy required to operate cooling system.

††Fixed charges are based on capital costs that are escalated to 1981 and include indirect costs. These costs are as follows:

Total Direct Costs (from Table 9.5-5)	12,458	13,854	17,848	8,676
Escalation and Indirect Costs	8,098	9,005	11,601	5,639
Total Capital Costs	20,556	22,859	29,449	14,315

Source: Black and Veatch, 1976.

Table 9.5-10 Capital Cost Summary*
Alternative Cooling Systems, Site 1C (Per Unit)

Item	Mechanical Draft Tower (Saltwater)	Mechanical Draft Tower (Freshwater)	Natural Draft Tower (Saltwater)	Natural Draft Tower (Freshwater)	Spray/ Dilution System	Once-Through Cooling
Condenser	$5,000	$4,500	$ 5,000	$ 4,500	$3,300	$ 3,300
Auxiliary Cooling	--	1,374	--	1,374	Base	Base
Intake System	1,030	--	1,030	--	3,116	1,558
Piping System	928	928	760	684	7,498	7,498
Cooling Tower	6,300	6,000	8,400	7,560	--	--
Pumping System	1,800	1,620	1,800	1,620	2,457	1,638
Spray System	--	--	--	--	4,350	--
Canal and Outfall	--	--	--	--	1,730	403
Well Field Pipeline	1,040	2,498	1,040	2,498	1,040	1,040
Comparative Direct Costs	16,098	16,920	18,030	18,236	23,491	15,437
Differential Costs	661	1,483	2,593	2,799	8,054	Base

*All values presented in thousands of dollars (1977).

Source: Black and Veatch, 1977.

Table 9.5-11 Annual Costs*
Alternative Cooling Systems, Site 1C (Per Unit)

Item	Mechanical Draft Tower (Saltwater)	Mechanical Draft Tower (Freshwater)	Natural Draft Tower (Saltwater)	Natural Draft Tower (Freshwater)	Spray/ Dilution System	Once-Through Cooling
Fuel†	$ 726	$ 726	$ 455	$ 455	Base	Base
Energy**	2,803	2,803	2,087	2,046	3,288	1,754
Demand Charge	1,302	1,302	1,141	1,121	835	417
Fixed Charges††	3,654	3,879	4,133	4,181	5,385	3,539
Operation and Maintenance Costs	240	271	226	254	642	308
Total Annual Cost	8,725	8,981	8,042	8,057	10,150	6,018

*All values presented in thousands of dollars (1977)
†Represents lost efficiency in steam cycle.
**Represents energy required to operate cooling system.
††Fixed charges are based on capital costs that are escalated to 1981 and include indirect cost. These costs are as follows:

Item	Mechanical Draft Tower (Saltwater)	Mechanical Draft Tower (Freshwater)	Natural Draft Tower (Saltwater)	Natural Draft Tower (Freshwater)	Spray/ Dilution System	Once-Through Cooling
Total Direct Cost	16,098	16,920	18,030	18,236	23,491	15,437
Escalation and Indirect Cost	10,263	10,786	11,494	11,625	14,976	9,841
Total Capital Cost	26,360	27,706	29,524	29,861	38,467	25,278

Source: Black and Veatch, 1977.

Table 9.5-12 Cooling System Maintenance Cost, Crystal River Unit 4 Preliminary Estimates*

	Mechanical Draft Cooling Tower Saltwater	Natural Draft Cooling Tower Saltwater	Pump Spray Modules and Dilation Pumps	Once Through Saltwater Cooling System
Chemical Injection Cost--Circulating Water †	--	--	--	--
Chlorination	23,200	23,200	46,500	46,500
Wellfield Maintenance	1,200	1,200	1,200	1,200
Towers--Fans, Motors	29,700	--	--	--
Towers--Interior Painting	4,700	28,000	--	--
Towers--Deterioration	19,000	26,000	--	--
Towers--Cleaning	13,900	13,900	--	--
Intake Structure	16,250	16,250	97,500	65,000
Traveling Screens	8,550	8,550	39,400	39,400
Seaweed and Grass	27,600	27,600	60,000	60,000
Circulating Pumps	15,600	15,600	54,600	31,200
Pump/Spray Modules	--	--	274,000	--
Substation Cleaning	67,500	52,600	47,800	47,800
Operator Inspections	12,600	12,600	21,000	16,800
Total Annual Maintenance	239,800	225,500	642,000	307,900

Table 9.5-12 Cooling System Maintenance Cost, Crystal River Unit 4 Preliminary Estimates (Continued, page 2 of 3)

	Natural Draft Cooling Tower Fresh Water Wellfield	Mechanical Draft Cooling Tower Fresh Water Wellfield	Natural Draft Cooling Tower Fresh Water Lake Rousseau	Mechanical Draft Cooling Tower Fresh Water Lake Rousseau
Chemical Injection Cost--Circulating Water †	146,000	146,000	--	--
Chlorination	4,900	4,900	7,300	7,300
Wellfield Maintenance	3,500	3,500	--	--
Towers--Fans, Motors	--	21,200	--	21,200
Towers--Interior Painting	--	--	--	--
Towers--Deterioration	18,600	14,300	18,600	14,300
Towers--Cleaning	9,100	9,100	10,300	10,300
Intake Structure	--	--	7,100	7,100
Traveling Screens	--	--	4,600	4,600
Seaweed and Grass	--	--	18,400	18,400
Circulating Pumps	11,600	11,600	11,600	11,600
Pump/Spray Modules	--	--	--	--
Substation Cleaning	47,800	47,800	47,800	47,800
Operator Inspections	12,600	12,600	37,800	37,800
Total Annual Maintenance	254,100	271,000	163,500	180,400

Table 9.5-12 Cooling System Maintenance Cost, Crystal River Unit 4 Preliminary Estimates (Continued, page 3 of 3)

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*This cost is necessary to allow a higher number of cycles of concentration for the wellfield alternative. A high number of cycles of concentration may also be used with water from Lake Rousseau without treatment because of its superior quality. All saltwater cooling tower alternatives have a lower number of cycles of concentration and use more makeup water.

The estimates presented show only predictable maintenance costs for work usually done during planned outages.

Source: Florida Power Corporation, 1978.

Table 9.5-13 Summary of Cost Estimates for Cooling Water Management Alternatives at Crystal River Power Plant*

Cost Item	Power Plant Units Covered	Closed Circuit Alternatives ($$10^6$)				
		Multi-Cell Mech. Draft	Circular Mech. Draft	Natural Draft	Fan-Asstd. Nat. Draft	Modular Spray Units †
Capital Investment, Equipment and Installation**	#3	32.8	37.2	53.6	39.2	36.5
Present Worth 1978 U.S. Dollars	#3	59.0	64.1	76.3	64.7	53.5
Annual Costs Capital Amortization Operation and Maintenance	#3	9.2	10.1	12.4	10.2	8.7
Capital Investment, Equipment and Installation	#1, 2, 3	61.5	63.7	83.9	72.4	64.1
Present Worth, 1978 U.S. Dollars	#1, 2, 3	118.4	125.0	136.0	126.4	102.9
Annual Costs, Capital Amortization Operation and Maintenance	#1, 2, 3	17.9	18.9	21.2	19.4	16.1

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*Table was adapted from Gilbert Associates (1974). Assumptions include: plant life = 30 yrs; load factor = 0.70 for Units 1-3, 0.75 for Unit 3; cost of capital = 11.25%; fixed charge rate = 17.3%; fuel = $0.020/kwh; capacity = $250/kw; 1% of yr hot enough to impose turbine penalty; once-through cooling system used as base cost.

Table 9.5-13 Summary of Cost Estimates for Cooling Water Management Alternatives at Crystal River Power Plant* (Continued, page 2 of 2)

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†Estimated on the basis of average cost ratios for Unit 3/Units 1-3 for other cooling alternatives.

**Tower design factors are: T (range), T (wet bulb), T (approach), °F = 15.1, 79, 12, respectively, except Nat. Draft and Spray Modules for which T (approach) = 14, 16, respectively.

Source: Kemp, 1977.

Table 9.5-14 Capital Cost Data Comparison

Cooling System	Black and Veatch, 1977, Proposed Crystal River Units 4 & 5, Per Unit Cost (10^3\$)/mw (1977 Dollars)	Rank	Kemp, 1977, Existing Crystal River Units 1, 2 & 3 Combined Cost (10^3\$)/mw (1974 Dollars)*	Rank	U.S. EPA, 1973, General for Nuclear Plant Cooling Systems Cost (10^3\$)/mw (1973 Dollars)	Rank
Once-Through Cooling	24.5	1	Base	1	3-5	1
Mechanical Draft Cooling Tower	25.5-26.9	2	35.1-36.4	2	8-11	3
Natural Draft Tower	28.6-28.9	3	41.3-47.9	4	9-13	4
Modular Spray Units	37.3	4	36.6	3	7-10	2

*These costs reflect costs of retrofit for existing units at Crystal River and would thus be higher than costs for new units.

Source: Environmental Science and Engineering, Inc., 1978.

TECHNICAL CONSIDERATIONS

All of the cooling systems considered are technically feasible. Technical considerations are reflected to a great extent in the economic rankings presented in the previous section. Once-through cooling is the system most widely used by Florida utilities. A ranking of cooling systems considered according to number in use throughout the United States most probably would reveal the following ranking:

1. Once-through cooling,
2. Mechanical draft cooling,
3. Natural draft cooling,
4. Dry and wet/dry cooling, and
5. Power spray modules.

Reliability of each of these systems is high enough to make all of them technically available for cooling consideration for the proposed units. Significant differences in operation and maintenance could emerge once a source of cooling water is selected. For example, few saltwater cooling towers are in operation at this time due to lower heat transfer, less evaporative heat loss, and higher corrosion properties of saltwater.

Comparison of Freshwater Versus Saltwater Cooling Systems

As previously discussed, the design and performance analyses of cooling systems are based upon thermodynamic principles and atmospheric conditions. The same major components are required for freshwater and saltwater systems. In the case of saltwater cooling systems, it is necessary to consider the incremental effects of salt concentration upon the design and performance characteristics. The major influences of salt water on the performance of cooling towers are:

1. A reduction in evaporative heat loss, since the vapor pressure of salt water is lower than that of fresh water;
2. Lower heat transfer in the condenser due to the lower specific heat, lower thermal conductivity, higher viscosity, and higher density of salt water than fresh water; and
3. Increased corrosion.

The design specifications for any saltwater system must be modified to maintain performance and counteract corrosion. There are several strategies for developing a satisfactory design for saltwater cooling towers. However, the net result is an incremental increase in the capital and operating costs of saltwater towers relative to those of freshwater towers. The specific problems that the design engineer must overcome in developing a saltwater cooling system are discussed in the following paragraphs.

Make-Up Water Requirements

A saltwater system would operate at a maximum of 1.3 to 2.0 cycles of concentration and would require between 45 and 95 cubic meters (12,000 and 25,000 gallons) per minute per unit saltwater makeup. A freshwater system operating under the same thermal load requirements would operate at much greater cycles of concentration and would require only 6,944 gallons per minute of make-up water per unit.

Blowdown Volume and Quality

The volume of blowdown water from a saltwater cooling tower will be three to four times as great as from a freshwater cooling tower. The salinity of saltwater blowdown would be approximately 50,000 milligrams per liter. Total dissolved solids in the blowdown of a freshwater tower would be an order of magnitude less.

Scale Treatment

Calcium, magnesium, and silica dissolved in cooling water are responsible for the formation of scale on heat transfer surfaces. The primary cause of scale formation is the decrease in solubility of the scale-forming salts ($CaCO_3$, $MgCO_3 \cdot 3H_2O$, $Mg(OH)_2$, and $CaSO_4$) with an increase in temperature. However, the solubility of these salts is increased by the presence of other ions in solution (the "salt effect").

Sulfuric acid treatment is a common practice to prevent scale formation in freshwater cooling systems. However, the "salt effect" in saltwater systems may make acid treatment unnecessary. The decision whether or not to use acid treatment must be made on an individual basis once operating characteristics are developed.

Corrosion Treatment

Corrosion treatment is very critical to the long-term operation of a cooling system. Freshwater cooling systems are generally protected with non-chromate inhibitors in a wide variety of proprietary formulations. The high chloride concentrations in saltwater systems accelerate corrosion and inhibit the formation of protective coatings by chemical inhibitors. Corrosion treatment for saltwater systems is much more complicated and expensive than for freshwater systems. The potential for discharge of concentrations of environmentally undesirable chemicals is also higher in a saltwater system.

Fouling Treatment

Fouling is the deposition of suspended material from the recirculating water. Fouling leads to reduced heat transfer, increased resistance to water flow, and severe localized corrosion. Sources of fouling are: (1) silt and other suspended materials in the makeup waters; (2) airborne particulate matter deposited into the tower via incoming air; (3) leakages and spills from the operating plant; (4) suspended materials resulting from deterioration of the cooling tower timber; and (5) biological growths. Biological fouling, the most serious fouling problem, will be discussed in a later subsection.

When estuarine water is used, the amount of suspended materials is often high. This high level of suspended materials causes increased fouling problems, especially in basins where the flow rate is low. Screening of entraining waters may not be sufficient to control fouling, and chemical treatment may be necessary. Airborne particulate matter may include a variety of materials, depending upon the location, and industrial and agricultural activities in the vicinity of the tower. Since these particles cannot be controlled externally, chemical treatment of the water is necessary. If wood is used, fouling due to deterioration should be controlled by chemical treatment.

If ground waters are used for freshwater makeup, fouling should be minimal due to the expected low concentrations of suspended organic material. Studies are being initiated to determine the suspended solids characteristics of potential surface water sources.

Biological Fouling

Sunlight, increases in temperature, and concentrations of bacteria, food, and airborne contaminants in a cooling tower environment result in the growth of algae, fungi, and bacteria. Algae will primarily be limited to those areas of the cooling tower exposed to sunlight. Slime is composed of bacteria, fungi, yeast, and in some cases, protozoa. Slime is found in the darker areas since the slime constituents do not synthesize their own food (like algae), but get it from the cooling waters. Slime deposits can retard heat transfer and cause serious pitting on metal surfaces.

Seawater fouling organisms are generally larger than those in fresh water. Some of these organisms are seaweeds, sea-acorns, mussels, and other testaceans. These marine organisms can reach sizes big enough to cause blockage of pumps, cooling water channels, and pipes. Where, as here, the asiatic clam Corbicula is present, significant fouling can occur in freshwater systems as well.

A variety of organic compounds and inorganic chemicals such as chlorine and bromine are employed to control biological growth in the recirculating cooling water. These biocides are supposed to kill or inhibit the growth of undesirable organisms. Many of these compounds kill bacteria at high concentrations and inhibit their growth in lower concentrations; however, in extremely diluted concentrations bacteria growth may be stimulated. Proper concentrations of chlorinated phenols, acrolins, and quaternary ammonium compounds are efficient biocides; however, chlorine is the most economical method of treatment and is thus the most widely used. Chlorine concentrations should be kept below 0.5 ppm to prevent cooling tower wood deterioration and adverse environmental effects on aquatic life at the discharge. If chlorination in low concentrations in unsuccessful in reducing or eliminating bacteriological fouling, a combination of chlorination and other biocide treatment may be employed.

Chlorination can be applied constantly in low concentrations or intermittently in higher concentrations (shock treatment). A continuous low degree of chlorination of 0.1 ppm is preferred to an intermittent supply of several ppm. Intermittent chlorination application may allow organisms such as mussels and barnacles to close themselves under adverse water conditions (high chlorination levels) and open up when conditions improve (chlorine concentration drops). Survival of these organisms may cause clogging problems.

Salinity in high concentrations has been proved to be toxic to many estuarine organisms. The high salinity in the basin may serve as a biocide to such organisms. Mussels and barnacles will probably close their shells, thus escaping injury. Some micro-organisms may tolerate salt concentrations, but for other organisms salt concentrations may be detrimental.

Turbine Generator--Condenser Design

Specific heat and thermal conductivity decrease with increasing salinity, whereas viscosity increases with salinity; thus condensers must be larger and circulating water flows greater in order to maintain a given heat removal rate when salt water rather than fresh water is used. The cooling tower and pump capacity must be increased in size to accommodate the larger flow rates. Pump horsepower must be increased to circulate larger volumes of denser, more viscous salt water. Construction materials must be selected which are resistant to corrosive attack.

Cooling Tower Design

Vapor pressure of water decreases as salinity increases; therefore, saltwater cooling towers have a larger tower volume and/or an increased air flow rate than do freshwater towers of the same water flow rate and inlet and outlet temperatures. Air flow rate is generally increased to attain equivalent performance.

Natural draft towers in the United States have used fresh water almost exclusively. At present, there are two large saltwater natural draft towers in this country. These towers have accumulated about 5 unit-years of operation time. This operating experience is not sufficient to assess the nature and amount of corrosion which will occur over the life of the facility. As a result, nonpredictable maintenance problems could occur which may influence the reliability of the proposed facility.

ENVIRONMENTAL CONSIDERATIONS

Once-Through Cooling System Alternatives

The once-through cooling system proposed for Crystal River Units 4 and 5 would use the existing intake and discharge canals with some modifications. Dredging would be necessary to deepen the intake canal to 5.5 meters (18 feet) and the discharge canal to 4.6 meters (15 feet) and provide the volumes of water needed for once-through cooling design and to accommodate coal barges. Velocities in both the intake and discharge canal would be increased.

Studies associated with the existing three units of the proposed site have determined a number of impacts associated with once-through cooling. Generally speaking, the major environmental effects of once-through cooling fall into three groups:

1. Impingement, or the impacts associated with the screens which strain larger organisms from the incoming water;
2. Entrainment, or the impacts associated with passage through the power plant of smaller organisms than those affected by impingement; and
3. Impacts associated with organisms which are exposed to the heated plume from the plant.

Other alterations in the environment include alterations brought about by changes in existing circulation patterns and biocide treatments. Recent studies indicate that potentially toxic bromates may be produced by a sunlight-induced reaction in chlorinated sea water (Macalady, et al., 1977).

Screenwash sampling was conducted at Crystal River by the Florida Department of Natural Resources in 1969. These data are summarized by Grimes (1971). During 1973-1974, researchers from Florida Universities conducted a number of studies aimed at assessing the effects of once-through cooling at Units 1 and 2. Nuclear Unit 3 was under construction at that time. More recently, studies of impingement at Units 1, 2, and 3 were conducted to meet the requirements of NRC Environmental Technical specifications (NUS.1978). Further studies are also underway with regard to intake modifications since the studies of 1973-1974.

Mean daily impingement of finfish and invertebrates from the NUS 1978 study and from Snedaker's 1973-1974 study are presented in Tables 9.5-15 and 9.5-16. Also presented are comparable data from the Anclote Power Station near Tarpon Springs, Florida (Texas Instruments, 1977) and from Big Bend Power Station near Tampa, Florida (Conservation Consultants, 1977). Flow rates at Anclote and at Big Bend are much lower than those of Units 1, 2, and 3 at Crystal River. Impingement is therefore considerably high at the Crystal River site.

Table 9.5-15 Mean 24-Hour Impingement Rates of Finfish at CRPS Units 1, 2, and 3 (1977-1978), CRPS Unit 2 (1972-1973), Anclote Power Station (1976), and TECO-Big Bend Power Station (1976-1977). (Biomass data in kg)

Month	Crystal River Units 1, 2, 3 1977-1978 (1,318,000 gpm)		Unit 2 1972-1973* (328,000 gpm)		Anclote 1976† (723,000 gpm)		TECO-Big Bend 1976-1977** (723,000 gpm)	
	Number	Biomass	Number	Biomass	Number	Biomass	Number	Biomass
January	29,662	291.4	472	24.3	113	5.3		
February	20,187	96.0	1,728	50.6	111	5.8	52 (1976)	--
March	2,966	82.1	932	28.1	85	1.2	787 (1977)	--
April	2,734	32.2	333	11.9	80	1.9		
May	737	8.8	190,571	824.6	145	1.6	191	--
June	684	43.6	438	12.6	745	8.0		
July	1,071	36.2	2,384	12.6	118	2.5		
August	891	21.5	92	5.4	89	1.6	417	--
September	387	11.5	92	2.6	17	0.6		
October	568	15.3	298	5.8	72	2.6		
November	2,544	41.2	282	15.8	218	12.6	265	--
December	25,286	218.5	666	36.4	304	13.0		
MEAN	7,310	74.9	16,524	85.9	175	4.7	323	--

*Calculated from Snedaker (1974).
†Calculated from Texas Instruments (1977), Figures VII-4 and VII-5.
**From Conservation Consultants (1977), Table 7.2.

Source: NUS, 1978.

Table 9.5-16 Mean 24-Hour Impingement Rates of Invertebrates at CRPS Units 1, 2, and 3 (1977-1978), CRPS Unit 2 (1972-1973), Anclote Power Station (1976), and TECO-Big Bend Power Station (1976-1977). (Biomass data in kg)

Month	Crystal River Units 1, 2, 3 1977-1978 (1,318,000 gpm)		Unit 2 1972-1973* (328,000 gpm)		Anclote 1976† (723,000 gpm)		TECO-Big Bend 1976-1977** (723,000 gpm)	
	Number	Biomass	Number	Biomass	Number	Biomass	Number	Biomass
January	5,179	31.3	298	2.0	143	0.2		
February	2,961	13.2	220	2.0	168	0.4	409 (1976)	--
March	2,771	24.2	131	1.0	490	2.3	408 (1977)	--
April	1,015	32.2	180	18.8	489	29.0		
May	345	26.7	89	7.0	350	14.2	152	--
June	567	6.2	316	3.2	1,525	7.4		
July	2,943	16.8	789	2.6	336	5.5		
August	2,749	17.4	59	0.4	636	3.8	422	--
September	1,557	39.3	84	0.6	145	8.9		
October	651	13.2	699	1.1	131	29.8		
November	1,852	28.5	84	0.5	139	29.8	185	--
December	1,047	21.6	508	2.4	150	6.6		
MEAN	1,970	22.6	288	3.5	392	11.5	292	--

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*Calculated from Snedaker (1974).
†Calculated from Texas Instruments (1977), Figures VII-4 and VII-5.
**From Conservation Consultants (1977), Table 7.2.

Source: NUS, 1978.

Grimes' 1969 collections (summarized in 1971) contained 59 species of finfish and 15 species of macroinvertebrates. Both number of species and numbers of individuals were low in summer and high in March and in fall. Snedaker's collections in 1972, 1973, and 1974 included 152 species of fish and 34 species of invertebrates with 10 species contributing over 95 percent of the total impinged biomass. Most common species were the polka-dot batfish, and striped burrfish, and blue crab, and squid (Snedaker, 1974). Slightly less than 8 percent of the impinged biomass was composed of species of economic importance. The NUS study was conducted in 1977 and 1978, at which time 106 species of finfish and 45 species of invertebrates were collected. Eleven species of finfish accounted for 94 percent of the total number of fish individuals captured. Table 9-5.17 presents ranking (highest to lowest) of species of biomass collected during the two impingement studies conducted at Crystal River. NUS estimated that impingement at all three existing units amounted to about 0.5 percent of the number of blue crabs taken commercially in the Citrus-Pasco County area in 1976. Impingement of pink shrimp was estimated to be about 1 percent of the number caught commercially in the Citrus-Pasco County area.

If once-through cooling is employed for Units 4 and 5, total numbers and weights of impinged organisms would undoubtedly increase since both flow rate and water volume used by the power complex would increase under present designs. Increased flow rate may increase the incidence of impingement for some organisms which currently may be able to avoid the screens. Increased volumes may be expected to increase the total number of species impinged.

Maturo, et al. (1974) estimated that between 900 and 2,300 kilograms (2,000 and 5,100 pounds) per day of biomass were entrained by Units 1 and 2, and that about twice these figures would be entrained by Units 1, 2, and 3 operating together. Assuming that Units 4 and 5 might entrain about as much as Units 1 and 2, the total entrainment for all five units using once-through cooling might be as high as 2,700 to 6,950 kilograms (6,000 to 15,300 pounds) per day. Mortality of entrained individuals

Table 9.5-17 Ranking (Highest to Lowest) of Species by Biomass Impinged at CRPS (1977-1978, 1972-1973) and at Anclote Power Station (1976)

Crystal River (1977-1978)	Crystal River (1972-1973)	Anclote (1976)
Scaled sardine	Atlantic threadfin	Horseshoe crab
Polka-dot batfish	Polka-dot batfish	Blue crab
Blue crab	Striped burrfish	Striped burrfish
Pink shrimp	Blue crab	Pink shrimp
Sea catfish	Scrawled cowfish	Atlantic stingray
Silver perch	Tunicates	Spotted eagle ray
Pinfish	Pinfish	Scrawled cowfish
Atlantic thread herring	Squid	Southern puffer
Scrawled cowfish	Silver perch	Spot
Bay anchovy	Pink shrimp	Spider crab

Source: NUS, 1978.

varies with species, age, sex, and other factors (Alden, 1976). A study of juvenile fish entrained by Units 1 and 2 (Florida Power Corporation, N.D.) provided an estimate that 2.4×10^8 individuals could be entrained in the worst case. Juvenile fish entrained by five units would be about three times this number. The biomass of the individuals killed or injured by the plant is not lost to the estuarine consumers. The consumer species may change to those more likely to receive sinking, non-moving prey (Alden, 1976). Maturo, et al. (1974) found in statistical analyses of zooplankton populations that increased flow rates were associated with negative effects on planktonic juveniles of fish and macroinvertebrates. Re-entrainment of discharge water, as predicted by Black and Veatch (1976), would multiply entrainment mortalities since weakened organisms may pass through more than once. Re-entrainment would also increase the temperature of the thermal plume. Generally, estuarine organisms are well-equipped by evolutionary processes to withstand thermal stress; however, the effects of higher temperatures are related in a complex manner to the length of exposure time, seasonality, and other environmental factors. While an organism may be tolerant to one temperature if not subjected for a long period of time, it may be killed if exposed for a longer period.

The extent of the thermal plume for Units 1 and 2 has been studied by Palmer and Carder (1975). Others have studied the effects of the plume upon organisms. Van Tine (1974) found that the biomass of algae and seagrasses was higher in the intake estuary than in the discharge estuary during most of the year. On an annual basis, the standing crop was about 43 percent higher on the intake side. Evink and Green (1974) reported the results of benthic sampling in the intake and discharge estuaries by means of 297 dropnet collections. The mean yearly invertebrate biomass for the discharge and intake was 2.46 g/m^2 and 9.62 g/m^2, respectively. Fish biomass was 6.1 g/m^2 in the intake and 5.16 g/m^2 in the discharge. These studies were conducted with Units 1 and 2 in operation. A larger plume resulting from all five units with once-through cooling would increase this area of impact.

Dredging operations required by the design for once-through cooling proposed by Black and Veatch (1976) would also have adverse environmental effects. Communities of bottom-dwelling organisms would be covered by spoil disposal. Despite efforts toward containment as a result of dredging, increased waterborne sediments would be dispersed to settle on other communities.

While specific studies of impingement, entrainment, and plume extent identified the community effects of once-through cooling, Odum, et al. (1975) examined the estuary at Crystal River from a systems standpoint. Energy cost-benefit analyses by this group indicated that when all energies contributed by man and nature are considered, energy flow associated with once-through cooling is about 1 percent of those required for cooling towers. Units 1, 2, and 3 were considered in that group of studies (see also Kemp, 1977).

Odum's conclusions were based on the fact that resources must be mined and processed elsewhere to produce cooling towers. These activities consume energy and produce various types of pollution elsewhere. When the entire process is considered, the total pollution produced versus the benefits derived were thought to be less beneficial to the entire system when the cooling towers are used.

The impacts of once-through cooling do not appear to be easily reduced since these impacts are connected with the large volume of flow required. The Gulf of Mexico is the only body of water in the site vicinity large enough to be used either as a source or a receiving body. Taking water from the Withlacoochee Reach of the Cross Florida Barge Canal has been suggested. Without detailed studies, it is not clear by what degree impingement and entrainment could be reduced under this plan. The destiny of the water body is uncertain as a part of the decision regarding disposition of the Barge Canal. It is not known whether the modifications thus far suggested will even be implemented in the Withlacoochee Reach or if they would be completed in time to meet the needs of the applicant.

Systems which somehow divert organisms away from the screens by noise, bubblers, etc., have not proven very effective (EPA, 1976). Sloped or horizontal screens with some bypass system to reduce impingement could be used. It does not seem economically feasible to reduce intake velocities to the recommended 15 centimeters per second (0.5 feet per second) for the volume of water required.

With the present system proposed by Black and Veatch (1976), the five units in operation on the same intake canal may increase total impingement by a factor greater than the proportion of increased flow. Fish and macroinvertebrates tired or injured by the intakes at Units 4 and 5 could be more easily impinged by the other three units.

A number of suggestions have been advanced to alter the present configuration of the canals. These all revolve around drawing water further offshore or discharging water further from shore. These measures will not necessarily lessen impacts since other populations would be affected. These populations would require study before any conclusions about relative impacts could be reached. Many estuarine organisms found inshore are more tolerant to thermal stress than closely-related offshore species. Furthermore, inshore systems have already adjusted to the stress, and changing the placement of the plume would require a new adjustment process.

Considering all factors, once-through cooling for Crystal River Units 4 and 5 would not appear to be the best available technology. It is highly unlikely that Units 4 and 5 would be licensed without extensive environmental studies. The status of Units 1, 2, and 3 is still undetermined. The Southwest Florida Water Management District has suggested that the once-through cooling system for power plants could be combined with a desalinization process (SWFWMD, 1977). This would allow power plants to produce rather than consume fresh water.

Cooling Towers

In general the effects of cooling towers on the environment include the following factors:

1. Fogging;
2. Icing caused by cold weather fogging;
3. Deposition of chemically-laden drift particles, especially when saltwater makeup water is used;
4. Consumptive use of water;
5. Climate modification due to the atmospheric discharge of heat and water vapor;
6. Effects on receiving water as a result of blowdown discharge;
7. Acid rainout due to mingling of cooling towers and stack gas plumes; and
8. Noise.

These factors are those summarized by EPA researchers (Shirazi, et al., 1977).

Factor 6 will be discussed in a later section which deals with the discharge of cooling water for the proposed site. Factor 2 is not a realistic concern for the climate of the Crystal River area. Factor 4 is discussed in Section 9.4.

Fogging problems were found to be related to climatic conditions which are conducive to natural fog formation. Shirazi, et al. (1977) reported the work of EG&G, Inc., 1971, which related the potential for fogging and climate modifications in the United States.

The proposed site is in an area which has a low potenital for fogging and climatic modifications based on a number of meteorological criteria. This conclusion is based on typical cooling tower designs and is general in nature, but does assign a low probability of such problems to the area of Florida near the proposed site.

Acid rainout (Factor 7) is not considered to be likely at the proposed site if cooling towers are used. The plant stacks are planned to be much higher than the air exits for either mechanical or natural draft towers. Since low sulfur coals are planned as fuel and scrubbers will probably not be used, the gases leaving the stacks will be about 150°C (270°F). The spatial differences in discharge points, temperature and velocity differences, and the meteorology of the site suggest that acid rains are not likely. This aspect is discussed in more detail in Chapter 5.

Noise from cooling towers can be a problem in some areas. Several methods for the estimation of sound emissions can be found in Teplitzky (1977). Since the nearest residences are more than 3.2 kilometers (2 miles) from the proposed site, it does not appear likely that noise will be an important impact for either natural or mechanical draft towers (see Section 2.2.3 for nearby residences).

Salt or brackish water from the Gulf of Mexico or Crystal River would bring forth some concerns connected with deposition of salt on the surrounding area (Factor 3).

Salt Drift

A drift deposition estimate was performed for various cooling tower alternatives using the procedure developed by C.L. Hosler, Pennsylvania State University. The analysis considered site meteorological data including wind speed and direction. Drift rate values for saltwater cooling towers with new drift eliminator designs are estimated to be within the range of 0.002 to 0.005 percent of the total circulating water.

It was assumed that the towers would be equipped with high efficiency drift eliminators which would reduce the drift rate to 0.0005 percent of the circulating water flow rate. This level of drift is lower than that used in previous Crystal River studies by a factor of 10. Drift measurements at the Atlantic City Electric B.L. England Station have verified this assumption.

Drift analysis results for the three proposed plant site locations are plotted as isopleths on Figures 9.5-2, 9.5-3, and 9.5-4. Drift analysis results are not available for Location Variation 1c, however, the results may be similar to Location 1 with the pattern shifted to the east. Isopleths of 67 kilograms per hectare (60 pounds per acre) per year and 7 kilograms per hectare (6 pounds per acre) per year are shown. A value of 30 is equivalent to the natural background level. This means that the area at the 67 kilogram per hectare (60 pound per acre) per year isopleth will receive a deposition rate of 67 kilograms per hectare (60 pounds per acre) per year above ambient for a total deposition of 100 kilograms per hectare (90 pounds per acre) per year. At the substation, the deposition rate will be increased by about 7 kilograms per hectare (6 pounds per acre) per year for site alternatives 1 and 3, which is small in comparison to ambient levels. Although stations on the Atlantic Coast are experiencing background levels of 67 kilograms per hectare (60 pounds per acre) per year on the substation with no apparent operational problems (Black and Veatch, 1977), it has been stated that additional salt drift levels of 30 pounds per acre above ambient background would cause operational problems at this facility (Black and Veatch, 1980).

It is expected that a natural draft saltwater cooling operation at Crystal River will present only minor substation operational difficulties and that location of towers as shown for location 3 could affect other existing facilities.

Natural Versus Mechanical Draft Towers

The differences between natural and mechanical draft cooling towers with regard to environmental impact primarily involve the factors of noise, salt drift, and power consumption.

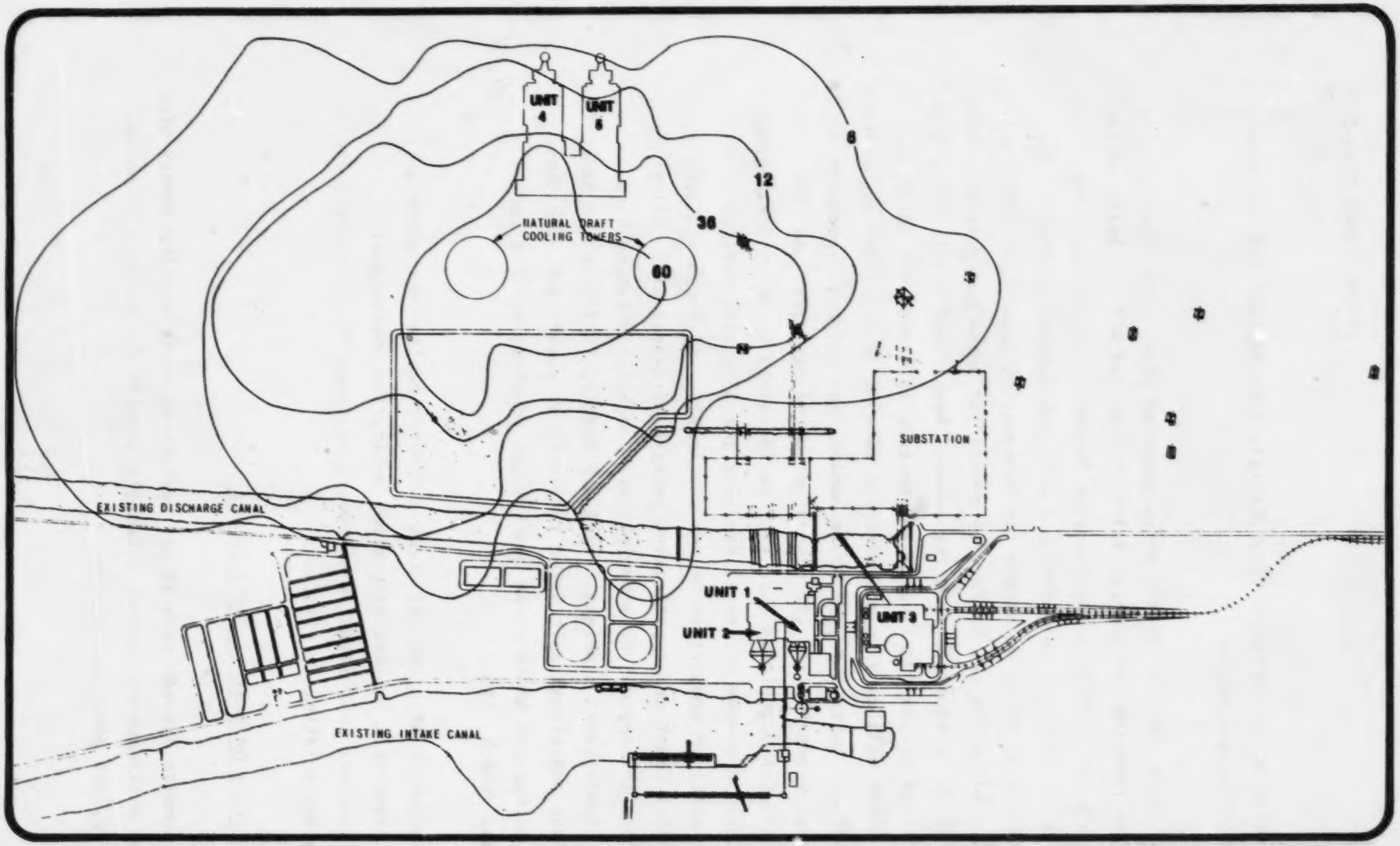

Figure 9.5-2

SALT DEPOSITION RATES - NATURAL DRAFT COOLING TOWERS, LOCATION 1
POUNDS/ACRE/YEAR

SOURCE: Black and Veatch, 1978

N

0 200 400 800
SCALE IN FEET

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

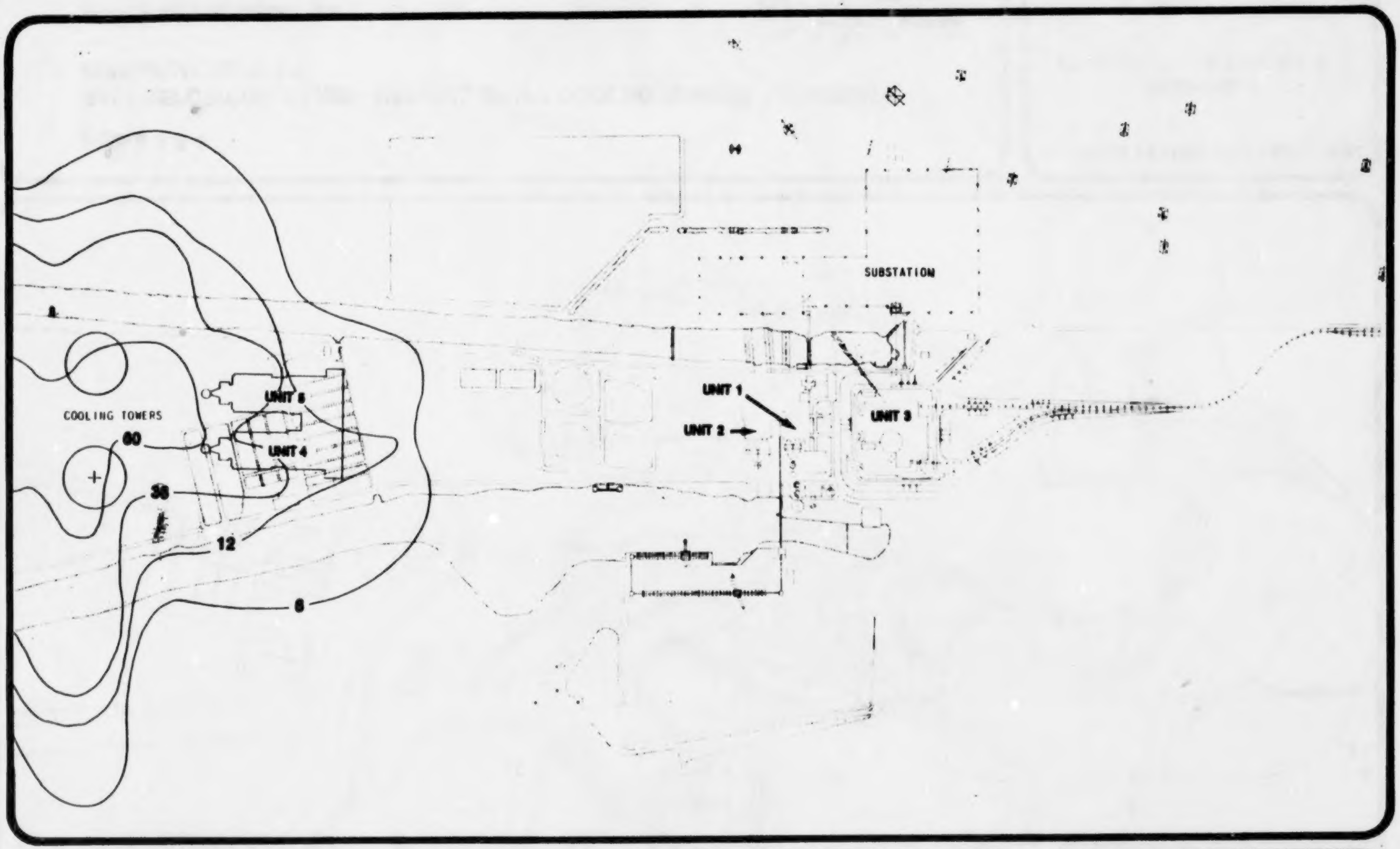

Figure 9.5-3

SALT DEPOSITION RATES - NATURAL DRAFT COOLING TOWERS, LOCATION 2
POUNDS/ACRE/YEAR

SOURCE: Black and Veatch, 1978

N

0 200 400 800
SCALE IN FEET

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

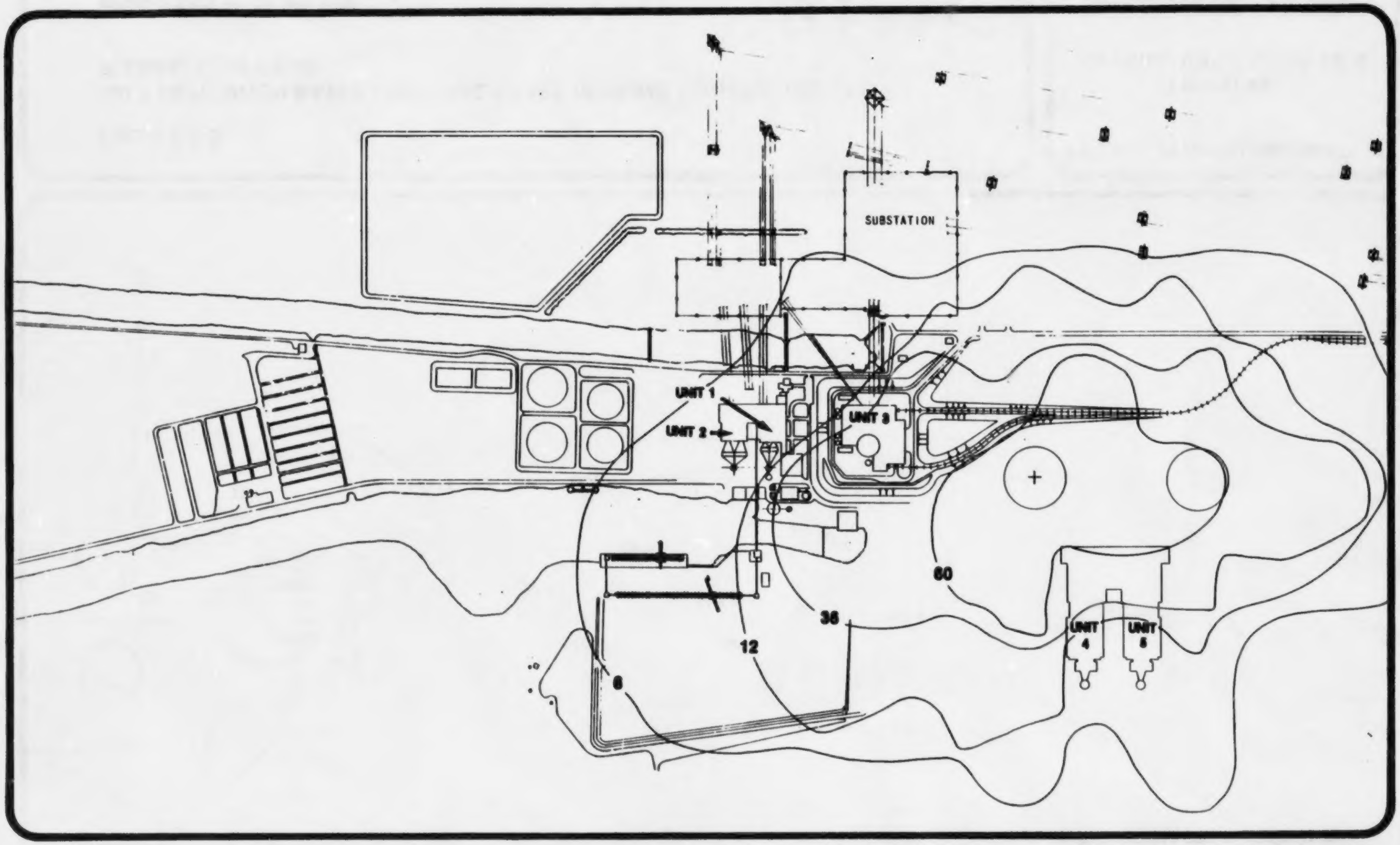

Figure 9.5-4

SALT DEPOSITION RATES - NATURAL DRAFT COOLING TOWERS, LOCATION 3
POUNDS/ACRE/YEAR

SOURCE: Black and Veatch, 1978

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

Noise from a mechanical draft tower should be greater than from a natural draft since fan sounds would be present in the mechanical draft tower. Even so, for the proposed secluded site it does not seem likely that noise would be of critical concern. Future development around the site during the plant's time of operation could change this (see other sections of this document). This noise is not thought to have adverse effects on wildlife (Edmonds, et al., 1975), because the noise is steady and is related to sounds of falling water.

Salt drift for mechanical draft towers in operation has not been studied in depth. EPA's test facility at Turkey Point studies the mechanical draft type (Shirazi, et al., 1977; Henderson and Dowdell, 1975). Salt deposition was not found to be significant with this experimental tower (Hindawi, et al., 1976). Black and Veatch (1976) estimates indicate that salt drift quantities may be higher for the mechanical draft tower than for the natural draft tower. As is the case with the natural draft cooling tower, use of fresh makeup water would eliminate concerns with salt drift.

Greater power consumption associated with mechanical draft towers would have an environmental impact. If more power is used in the cooling process, this power is lost to human use while contributing to air and water impacts.

Power Spray Modules

This cooling system would require additional dredging to accommodate a dilution flow rate of 63,100 liters per second (1 million gpm) (Black and Veatch, 1977). Both the existing intake and discharge canals would require widening under the design outlined by Black and Veatch. Dredging would result in the destruction of some terrestrial habitat, and the resulting turbidity changes and siltation in the open Gulf would have adverse impacts on estuarine organisms already under thermal stress from Units 1, 2, and 3. Salt drift from the PSM system would result in effects similar to either natural or mechanical draft cooling towers.

Concentrations of the drift would occur near the discharge canal and would be low. With the amounts of water necessary, it is not feasible to use fresh water in a PSM system to mitigate any salt drift problems.

9.5.5 SUMMARY

Because different types of cooling systems impact different components of the environment, it is often difficult to compare the environmental costs of the proposed systems. Systems ecologists working at Crystal River attempted to make such a comparison on the basis of total productivity lost.

Table 9.5-18 is an estimate of the total productivity lost as a result of thermal discharges from existing Units 1 and 2 once-through cooling; 803×10^3 kilocalories (coal equivalent calories)/ year per Mw of electricity generated (Kemp, 1977).

Data from Table 9.5-18 can be compared with the once-through impact data. Table 9.5-19 is an estimate of productivity loss due to effects of salt spray deposition as a result of cooling towers for existing Units 1, 2, and 3. Total loss due to salt deposition is $3,270 \times 10^6$ kilocalories (coal equivalent calories)/year. This is a loss of 1.866×10^6 kilocalories/year per Mw. Based on these data, Kemp (1977) concluded that environmental impacts in terms of loss of ecosystem primary production are twice that for cooling towers than for once-through cooling. It is recognized that this data cannot be directly extrapolated for proposed Units 4 and 5 due to possible synergistic effects of adding additional units to the site; however, it is relevant in a general sense in selecting a cooling alternative.

Table 9.5-20 lists advantages and disadvantages of various cooling alternatives considered.

Table 9.5-18 Estimates of the Energetic Impact of Discharges from Crystal River Power Plant Units 1 and 2 on the Surrounding Ecosystems, as Indicated by Changes in Community Gross Primary Productivity (Kemp, 1977)

Ecological Subsystem	$(PG_M \cdot r_M)$* Changes in Gross Productivity (kcal CE/$m^2 \cdot yr$)	(A) Affected Area ($m^2 x 10^6$)	(E_M) Energy Value Loss (kcal CE$x10^6$/yr)
Inner Bay †			
Control	673		
Discharge	386		
Change	287	0.93	267
Outer Bay**			
Control	509		
Discharge	476		
Change	33	1.81	60
Salt Marsh ††			
Juncus			
Control	1,570		
Discharge	985		
Change	585	0.76	445
Spartina			
Control	1,165		
Discharge	1,004		
Change	161	0.19	31
TOTAL CHANGE		3.69	803

*Abbreviations in column heading refer to Eq(34), Methods Section. Energy quality ratio, r_M, for gross productivity is from Odum, et al. (1975).

†Smith (1976).

**McKellar (1975).

††Productivity data from Young (1974b). Areas estimated from Klausewitz, et al. (1974), assuming 20 percent *Spartina* and 80 percent *Juncus* (Young, personal communication).

Source: Kemp, 1977.

Table 9.5-19 Effects of Salt Spray Deposition on Terrestrial Ecosystems for Alternative Cooling Water Management Schemes for Crystal River Power Plant Units 1, 2, and 3

Salt Deposition Rate g/m^2.yr	Calculations Parameters	Footnote	Multi-Cell Mechanical Draft	Circular Mechanical Draft	Natural Draft Tower	Fan-Asstd. Natural Draft
44-88	Area affected, m^{2}x10^6	*	1.40			
	Productivity, kcal CE/m^2.yr	†	992			
	Fractional reduction	**	0.40			
	Total Prod. Lost, kcal CEx10^9/yr		0.56			
2	Area affected, m^{2}x10^6	*	5.99	2.43		
	Productivity, kcal CE/m^2.yr	†	1073	1073		
	Fractional reduction	**	0.20	0.20		
	Total Prod. Lost, kcal CEx10^9/yr		1.29	0.52		
9-11	Area affected, 10^{6}m^2	*	12.67	28.87	5.95	1.03
	Productivity, kcal CE/m^2.yr	†	1117	1117	992	992
	Fractional reduction	**	0.10	0.10	0.10	0.10
	Total Prod. Lost, kcal CEx10^9/yr		1.42	3.74	0.59	0.10
Total effect, kcal CEx10^9/yr			3.27	3.74	0.59	0.10

*Areas affected by given level of salt deposition for given cooling alternative are estimated from isopleths of salt spray deposits calculated by Gilbert Associates (1974). Areas are prorated for higher possible salinity of spray (34 ppt).

†Vegetation maps of Dames and Moore (1974) show which ecosystems are affected by which levels of deposition. Weighted mean productivity for entire area is calculated assuming that the productivities (kcal CE/m^2.yr) for community types affected are: salt marsh=1385; pine flatwoods=595; planted pine=600; mesic hammock=830.

**Fractional reduction of production estimated from Mulchi and Armbruster (1975) data on corn for different salt loading rates.

Source: Kemp, 1977.

Table 9.5-20 Analysis of Alternative Cooling Systems: Environmental Considerations

	Advantages	Disadvantages
Once-through Cooling (estuarine water)	1. Low costs 2. No fresh water consumption* 3. Possibility of desalinization process	1. New dredging required 2. Impingement of large numbers of finfish and shellfish 3. Entrainment of large amounts of planktonic forms 4. Increased size of area swept by present thermal plume 5. Biocide additions
Natural Draft Cooling Towers with Freshwater Makeup	1. No salt drift 2. Area is rated low for fogging potential 3. Reduced volume of water means fewer organisms will be entrained if surface fresh waters are used	1. Consumptive use of fresh water 2. If groundwater is used, potential for salt water intrusion exists 3. Noise 4. Biocide and antiscaling chemical additions (fewer biocides if groundwater is used)
Natural Draft Cooling Towers with Saltwater Makeup	1. No consumption of fresh water* 2. Area rated low for fogging potentials	1. Potential for salt drift 2. Noise 3. Potential for increased technical problems due to corrosion 4. Biocide and chemical additions 5. Somewhat more flow required than if freshwater used. Increased entrainment of saltwater organisms

Table 9.5-20 Analysis of Alternative Cooling Systems: Environmental Considerations (Continued, page 2 of 2)

	Advantages	Disadvantages
Mechanical Draft Cooling Towers with Freshwater Makeup	1. No salt drift 2. Area rated low for fogging potential 3. Reduced volume of water flow than if saltwater is used. Fewer organisms would be entrained if surface fresh waters are used	1. Increased noise over natural draft tower 2. Higher initial and operating costs than natural draft tower 3. Consumes more power than natural draft tower. The power produced contributes to air pollution and discharge impact
Mechanical Draft Cooling Towers with Saltwater Makeup	1. No consumption of fresh water* 2. Area rated low for fogging potential	1. Increased noise over natural draft 2. Potential for salt drift greater than natural draft 3. Higher initial and operating costs than natural draft 4. Consumes more power than natural draft. Power produced contributes to higher air and water emissions 5. More water would be needed than if freshwaters are used. Leads to larger entrainment
Power Spray Modules (saltwater only)		1. Salt drift near canal 2. High costs 3. Large volumes of water needed. Leads to large impingement and entrainment 4. New dredging required

*Fresh water would still be required for boiler makeup and service water.

Source: Environmental Science and Engineering, Inc.

9.6 ATMOSPHERIC POLLUTION CONTROL SYSTEM ALTERNATIVES

9.6.1 OBJECTIVES

The immediate increased use of coal in conventionally-fired boilers is an integral part of any national energy scenario through the year 2000. There can be a substantial impact upon the public health and welfare due to as much as a six-fold increase in coal-fired generation (Balzhiser, 1977). Therefore, the increased use of coal-fired boilers will necessitate improvement of emission control technology.

As of the present time, New Source Performance Standards (NSPS) have been promulgated for emissions of sulfur dioxide, nitrogen oxides, and particulates emanating from coal-fired power generation units. Values of the NSPS in effect, as well as tighter standards, are being considered for the future. Interest in fine particulate matter, sulfates, trace elements, and polycyclics is increasing.

The constraints presented by the energy crisis and the NSPS have encouraged the development of advanced energy generation systems and novel pollution control methods. Some of the more progressive energy schemes employ simultaneous pollutant removal techniques.

Most alternative energy production and emission control methods are now in various stages of research and development. All are characterized by uncertainties in capital requirements, operating costs, and performance. The Electric Power Research Institute (EPRI) has performed comparative analyses for energy and pollutant control options for which design data are available (Balzhiser, 1977).

Of interest in this study is the category of direct-fuel utilization. Low-sulfur coal is considered to be the option which offers the lowest combined costs and presents the fewest uncertainties in the present stage of technical development and performance. For this reason, utility companies choose to burn low-sulfur coal in conventionally fired boilers when that alternative is available.

Low-sulfur coal can be obtained by the exploitation of naturally-occurring coal deposits in the Eastern and Western United States. It can also be obtained by the beneficiation and refinement of higher sulfur coals.

Low-sulfur eastern and western coals which, when burned, emit less than .54 kilogram (1.2 pounds) of sulfur dioxide per million Btu's of heat input, meet new plant emission standards and most State Implementation Plan (SIP) limits [Commerce Technical Advisory Board (CTAB), 1975)].

In the East, certain low-sulfur coals are generally reserved for the domestic steel industry or for exporting. However, seams of low-sulfur coal considered to have limited metallurgical value are available at premium prices.

In the West, development of low-sulfur coal is inhibited by limited water resources, transportation problems, and the environmental effects of strip mining.

Most of the western reserves underlie federally-owned lands. Plans to lease government-owned areas to mining companies have been frustrated by opposition on the grounds that the National Environmental Policy Act (NEPA) requirements for an Environmental Impact Statement (EIS) have not been fulfilled (Balzhiser, 1977).

The prospects are encouraging for obtaining low-sulfur coal if it is mined (U.S. Department of the Interior, Bureau of Mines, 1975). Much of the western coal, however, is sub-bituminous grade, has lower heat content, and contains a higher ash than eastern coals.

9.6.2 SULFUR DIOXIDE CONTROL ALTERNATIVES

Sulfur dioxide control alternatives may be categorized as follows:

1. Burning of low-sulfur coal, whether naturally occurring or upgraded.
2. Removal of sulfur dioxide from the flue gas. Flue gas desulfurization can be accomplished through non-resource recovery methods or by regenerative processes.
3. Removal of sulfur dioxide at the combustion stage.

Roughly half of the recoverable coal from Montana and Wyoming can meet the present NSPS without desulfurization of any kind. Of the portion which would cause emissions greater than allowed by the NSPS, most would require treatment levels between 1 percent and 40 percent (Figure 9.6-1). If the stringent standards in Balzhiser (1977) are adopted, over 75 percent of all Montana and Wyoming coal will require desulfurization.

The above analysis discusses mainly western coal. Eastern coal will be discussed in a subsequent section. Undoubtedly, what happens to western coal mining will affect the eastern price structure and electric utility decision making.

COAL BENEFICIATION

When low-sulfur coal is not available, a significant amount of high-sulfur coal can be beneficiated in order to meet the NSPS requirements. The only widely used method for treating coal to reduce its sulfur content is known as the sink-float method. This alternative is feasible when a large portion of the sulfur is present as iron pyrite.

Where organic sulfur is high (such as in northern West Virginia and western Pennslyvania coals), the float-sink method does not reduce sulfur sufficiently to meet NSPS requirements.

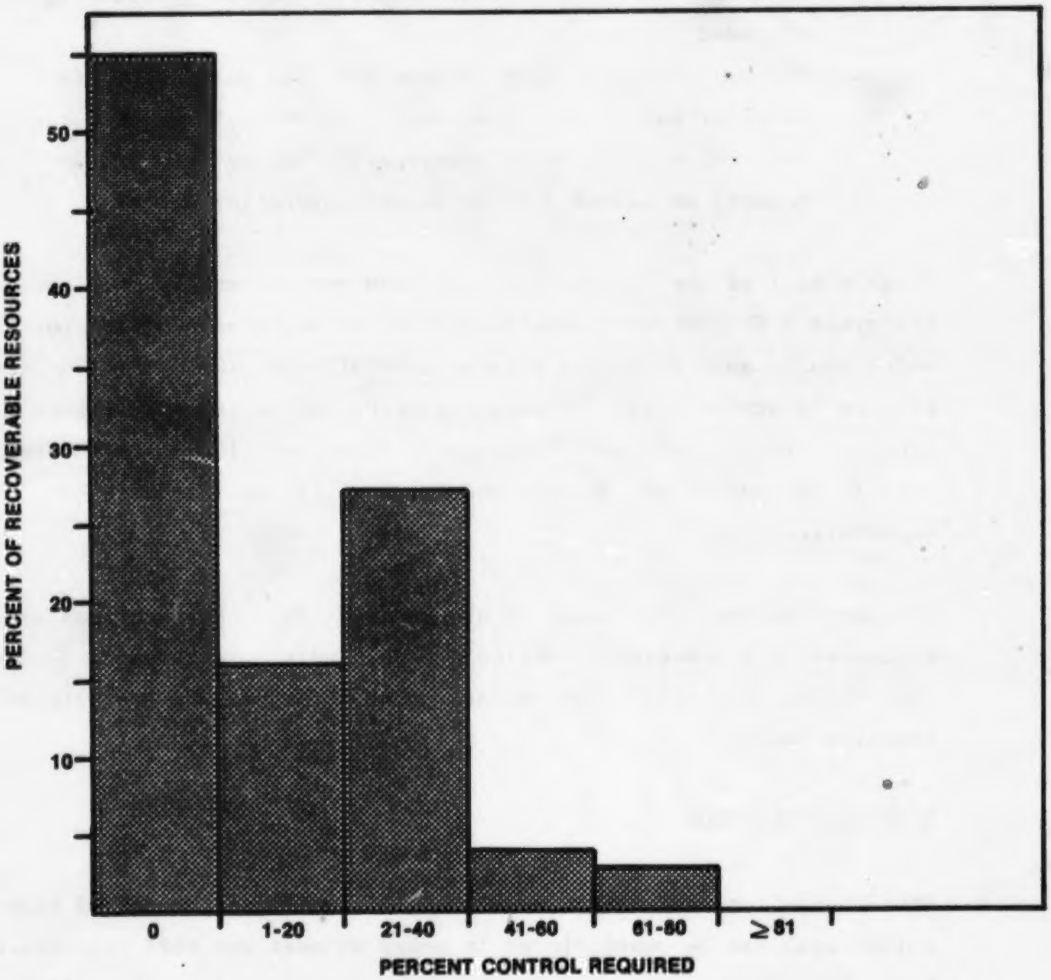

Figure 9.6-1
STATISTICAL DISTRIBUTION OF PERCENT CONTROLS REQUIRED FOR ALL RECOVERABLE RESOURCES IN MONTANA AND WYOMING

SOURCE: RENNE, 1976

FLORIDA POWER CORPORATION

PROPOSED
CRYSTAL RIVER UNITS 4 & 5

CITRUS COUNTY, FLORIDA

If applicable, beneficiation is the least costly sulfur dioxide control. It requires the lowest investment by a utility and displaces a substantial portion of the ash at the utility site to the mine site as refuse (CTAB, 1975).

According to the CTAB report, coal beneficiaton in conjunction with FGD is the "most economical best all around choice" for meeting the NSPS requirements quickly. In the report named above, it was assumed that lime/limestone flue gas desulfurization (FGD) is reliable and available.

Assumptions in the foregoing discussion were that regenerative processes were not available for immediate use on a large scale and that advanced power generating systems will not be available in the immediate future.

An estimated 13 percent of the United States coal reserves can meet the present NSPS. With coal beneficiation, approximately 28 percent of the coal reserves can meet the pollution criteria, and with chemical cleaning, 48 percent of the coal reserves become available without further treatment (Balzhiser, 1977).

SOLVENT REFINED COAL

Solvent refining is a method of chemically cleaning coal in order to remove the organic sulfur constituent. The most advanced process is one which includes a hydrogenation step. This generates a product of 8,900 kilocalories per kilogram (16,000 Btus per pound) from coal ranging between 4,400 to 6,700 kilocalories per kilogram (8,000 and 12,000 Btu's per pound) (Balzhiser, 1977). The material produced is chemically and physically different from coal, but preliminary combustion tests indicate that it will be a suitable boiler fuel and meet the current NSPS requirements. Although claims are made that the economics look favorable, in-depth analysis needs to be made regarding hydrogenation costs and hidden energy costs.

TRW, Batelle, and Atlantic Richfield companies are all developing chemical coal cleaning processes in which inorganic solvents are utilized. The Electric Power Research Institute (EPRI) is preparing to fund a project to combine organic and inorganic sulfur removal.

DYNAMIC EMISSION CONTROLS

Dynamic Emission Controls (DEC) are not built-in control methods, but rely upon the use of meteorological as well as ambient pollutant data as decision-making tools. Fuel and load switching are used to keep ambient emission standards from being violated. The economics of DEC are very appealing, but it might be difficult to enforce their use. DEC is not now available to FPC as an alternative.

Similarly, the use of tall stacks will effect significant reductions in ambient sulfur dioxide concentrations (Smith and Frankenberg, 1975). Tall stacks for control of pollutants do not provide for compliance with the NSPS. Also, limitations regarding stack height with respect to building height rule out this alternative.

HIGH SULFUR COAL--FLUE GAS DESULFURIZATION

Flue gas desulfurization (FGD) involves the removal of sulfur dioxide from the combustion gases by a positive control device. FGD processes are broken down into two major categories. They are:

1. Throwaway processes, where resource recovery is not practiced; and
2. Regenerative processes, where the removal media is regenerated and the sulfur recovered.

There are cases where recovery is an economically marginal consideration in one location, but is very favorable somewhere else.

Throwaway Processes

Throwaway processes are characterized by the use of either lime or limestone to remove sulfur at various points within the process. Several methods can be used. They are:

1. Use of lime or limestone slurry in a scrubber;
2. Use of lime to causticize an alkaline scrubbing solution while removing sulfur;
3. Injection of lime or limestone directly into the furnace; and
4. Fluidized Bed Combustion (FBC), which is in the developmental stage.

Several other methods can be used, including use of Nahcolite ore and bag filters (Genco, et al., 1975), but are at the pilot plant stage.

Wet Lime/Limestone Scrubbing

Lime and limestone FGD processes can chemically remove as much as 90 percent of the sulfur oxides from power plant flue gases by reaction with a slurry of lime or limestone in a scrubber. Heavy concentration of industries and the market for gypsum have resulted in a large number of successful commercial applications in Japan. The U.S. EPA in 1971 felt that FGD processes, particularly lime and limestone scrubbing, were commercially feasible in the United States. Table 9.6-1 is a summary of the operational and planned installations employing FGD. There are more units which use wet lime/limestone scrubbing than any other technique.

In the United States, wet lime/limestone scrubbing is a throwaway process, producing a sulfite/sulfate sludge which must be disposed. In Japan a further oxidation step is employed, and quality gypsum is produced.

Table 9.6-1 Number and Total Mw of Flue Gas Desulfurization (FGD) Systems in the United States

Status	No. of Units	Mw
Operational		
Active	23	4,693
Inactive	5	605
Under construction	18	6,171
Planning		
Contract awarded	10	3,761
Letter of intent	8	2,325
Requesting/evaluating bids	5	2,577
Considering FGD systems	46	24,007
Total	115	44,139

The results of commercial applications in the United States are mixed. Lime scrubbing is practiced at Duquesne Light Company's Elrama and Phillips Power Stations. According to Pernick and Knight (1976), problems have included:

1. Deposit accumulation in spray nozzles;
2. Corrosion/erosion problems with recycle pumps;
3. Deposits in scrubber vessel in venturi throat dampers, lower cone and elsewhere;
4. Unacceptable reliability; and
5. Duct deterioration.

The company is now using magnesium oxide modified lime in order to improve performance, thus adding to costs and to sludge disposal problems.

An alternative scrubbing process developed by Atomics International Division, Rockwell International Corporation, and Whellabrator-Frye, Inc., employs dry lime scrubbing in the absorption of SO_2 and a fabric filter to collect the resulting particulate matter. Pilot tests were performed in June, 1977, at Basin Electric Power Cooperative's Leland Olds Station in Stanton, North Dakota. Favorable tests resulted in a demonstration project at a planned 410 Mw coal-fired Coyote station (Focker, *et al*., 1978).

With the problems which can occur, many utilities still consider lime/limestone FDG to be in the development stage.

Because the U.S. EPA approves of FGD, and because FGD has demonstrated success outside the United States, utilities have searched thoroughly for ways to make FGD work. According to Beychock (1974), these include:

1. Having redundant units on hand as "spares" to avoid outages;
2. Liberal use of standby pumps, centrifuges, and other rotating machinery;
3. Employment of experienced chemical staff to operate what are essentially chemical processes; and

4. Planning and staffing for aggressive corrective maintenance during the startup of a major new unit.

In the previously mentioned study by the CTAB (1975), lime/limestone FGD was considered to be commercially available. Capital costs are substantial, and operating costs are close to those from use of low-sulfur coal. Total annual cost (which includes cost of capital) would be greater for lime/limestone FGD than for low-sulfur coal. The lead time is longer than for low sulfur coal.

In order to meet the immediate needs of sulfur dioxide control on a national scale, the CTAB recommended a combination of coal beneficiation coupled with lime/limestone FGD.

Double Alkali Scrubbing

The double alkali process, which has several variations, involves scrubbing flue gas with a soluble alkali such as sodium hydroxide, ammonia, or sodium sulfite, and regenerating the absorbent with an insoluble alkali such as lime. The double alkali process has the potential advantage of soluble alkali scrubbing with limited scaling, plugging, and erosion problems (Marten, 1977).

As in the case of lime/limestone scrubbing, most of the proven experience lies with Japanese installations. Nippon Kokan K.K., Showa Denko, and Kureha Chemical successfully demonstrated on a commercial scale before 1974 that double alkali scrubbing worked (Beychok, 1974).

In the United States, the process is at the research and development stage. Utah Power and Light's 100 Mw Unit 3 (Gadsby Station) was fitted with a pilot scale sodium hydroxide/lime process in 1971. A 20 Mw prototype double alkali system was operated between February, 1975, and July, 1976, at Gulf Power's Scholz Number 1 plant in Chattahoochee, Florida (Marten, 1977).

Government funded research is being conducted by the Bechtel Corporation at TVA's Shawnee Power Station, Paducah, Kentucky. Test results on parallel venturi scrubber/turbulent contact absorber installations (10 Mw each) are promising. Lime and limestone are being used for the second step (EPA, 1976).

Limestone Addition

The injection of limestone into the furnace as a sulfur removal method was practiced at Kansas City Power and Light's Hawthorne and Lawrence Stations. The method was advocated by Combustion Engineering. Many problems, including sulfur dioxide removal efficiencies between 20 and 35 percent, have caused this method to be abandoned.

Fluidized Bed Combustion

FBC is a modern outgrowth of limestone addition. Sulfur is captured by the limestone, and calcium sulfate is formed in a bed which is maintained at temperatures between 870°C and 900°C (1,600 and 1,650°F) (Balzhiser, 1977). DOE, EPA, and EPRI are supporting research and development in Atmospheric Fluidized Bed Combustion (AFBC). Scale-up of a modular unit to 100 to 200 Mw is expected in the early 1980's by DOE in Morgantown, West Virginia.

Regenerative Processes

Regenerative processes are characterized by regeneration of the removal medium and by recovery of the sulfur. Lime/limestone scrubbing falls under this category when gypsum is produced. When chemicals or methods besides lime and limestone are used, economic considerations always dictate regeneration/recovery.

The regenerative processes offer several advantages over the throwaway methods. These include (Murthy, et al., 1976):

1. There is no sludge or filter cake to dispose of;
2. Pure sulfur dioxide, sulfur, or sulfuric acid is produced; and
3. There are significantly reduced quantities of secondary waste streams.

The disadvantages are due to:

1. Up to 5 percent increased energy input for supplying reducing gases; and
2. Higher investment and operating costs.

Most types of these flue gas desulfurization processes are in the developmental stage.

One of the major problems plaguing many regenerative processes is the need for reducing agents such as hydrogen sulfide, hydrogen, carbon monoxide, and coal. Those FGD processes that require a reducing gas or solid are listed in Table 9.6-2.

A status summary of regenerative processes is presented in Table 9.6-3. The list is by no means exhaustive, considering Japanese experience. The only feasible alternatives for FPC are:

1. Magnesium oxide scrubbing,
2. Catalytic oxidation,
3. Sodium sulfite scrubbing, and
4. Sulfuric acid scrubbing.

Regenerative processes hold some future promise for Florida. The electric power industry can conceivably sell recovered sulfur, sulfur dioxide, or sulfuric acid to the phosphate industry, which in turn can use the product to acidulate phosphate rock for the production of fertilizer. The quantity of sulfur which electric companies can produce is on the order of magnitude of requirements of the phosphate industry.

Table 9.6-2 Flue Gas Desulfurization (FGD) Processes Which Require a Reducing Gas or Solid

Gas or Solid	Type of FGD Process
1. Hydrogen Sulfide for direct use in process	a. Citrate b. Stauffer c. Catalytic--IFP D. Westvaco
2. Hydrogen	a. Shell (SFGD) b. Alakalized alumina
3. Carbon Monoxide	a. Consol-aqueous potassium salts
4. Hydrogen Sulfide for Claus Plant[a]	a. Wellman-Lord b. Stone and Webster/Ionics c. Ammonia Scrubbing d. Bergbau-Forschung (if RESOX is not used) e. Shell
5. Coal (coke)	a. Foster Wheeler's RESOX process in FW-BF b. Al-ACP c. MgSO4 regeneration (MgO process)

a. Note that concentrated SO_2 from processes 4(a) through 4(e) can be converted to sulfur by the RESOX process or the ASARCO-Phelps Dodge direct sulfur process.

Source: Murthy, 1976.

Table 9.6-3 Brief Status Summary on Regenerative Processes*

Process Name	Year, Installation Site, Vendor, Size, and Type of Boiler	Status
MgO scrubbing	1972, Mystic, Boston Edison, Chemico, 150 Mw, oil 1974, Dickerson, Potomac Electric, Chemico, 100 Mw, coal 1975?, Eddystone, Philadelphia Electric, UEC, 120 Mw, coal	Shut down since June, 1974 Shut down since July, 1975 Shut down for modification
Wellman-Lord	1975?, D.H. Mitchell, NIPSCO, Davy Powergas/ Allied Chemical, 115 Mw, coal	Under construction
Cat-Ox	1972, Wood River, Illinois Power Company, Monsanto, 110 Mw, coal	Shut down since 1974
Chiyoda CT-101	1975, Scholz power plant, Gulf Power Company, Chiyoda, 23 Mw, coal	Operating since June, 1975
Citrate †	1973, Pfizer's Vigo Chemical Complex, McKee/Peabody, 1 Mw slipstream coal	Shut down September, 1974, after data collection
Phosphate	1974, Norwalk Harbor Station, Connecticut Power and Light Company, Stauffer, 0.1 Mw, oil	Shut down June, 1974, after data collection

Table 9.6-3 Brief Status Summary on Regenerative Processes* (Continued, page 2 of 3)

Process Name	Year, Installation Site, Vendor, Size, and Type of Boiler	Status
Catalytic-IFP	No data in open literature	No data in open literature
Consol-potassium salts	1972, Cromby, Philadelphia Electric Company, Consol/Bechtel, 10 Mw, coal	Shut down since 1972 after data collection (a smaller plant, 1000 acfm was operated until 1975)
Al-ACP	1971, Mohave, So. California Edison, Al, 0.5 Mw, oil	Shut down 1972 after data collection on open-loop system
FW-BF	1975, Scholz power plant, Gulf Power Company, Foster Wheeler, 20 Mw, coal	Started commissioning January, 1975, many problems

Table 9.6-3 Brief Status Summary on Regenerative Processes* (Continued, page 3 of 3)

Process Name	Year, Installation Site, Vendor, Size, and Type of Boiler	Status
Westvaco	1970, Westvaco Research Center, Westvaco, 0.2 Mw, oil	Shut down 1974 after data collection
SFGD	1974, Big Bend Station, Tampa Electric, Shell, 0.6 Mw, slipstream, coal	Tests are in progress

*Only installations in the United States are discussed in this table.

†Extensive pilot plant studies on a lead smelter gas are being conducted by USBM Salt Lake City Metallurgy Research Center.

Source: Murthy, 1976.

Magnesium Oxide Scrubbing

This process was the first commercially demonstrated sulfur removal-regeneration process. It operates similarly to lime scrubbing with the exception that a slurry of magnesium oxide was used instead.

Spent magnesium sulfite/sulfate from the Boston Edison Mystic Station was transported to a regeneration plant in Rumford, Rhode Island. Sulfuric acid was produced and magnesium oxide was regenerated. The unit at Boston Edison was shut down in 1974 after the closing of the regeneration plant. Adoption of magnesium oxide scrubbing in Florida would require a central regenerating plant.

Catalytic Oxidation

Catalytic oxidation employs a vanadium pentoxide catalyst which converts sulfur dioxide to sulfur trioxide. A solution of sulfuric acid is the ultimate product. The process was demonstrated on a 110 Mw coal-fired unit at Illinois Power Company. At the time, more effort was required to make the process work than was realized, and the result was that installation, though theoretically quite feasible, was shut down. It could probably work if sufficient interest and funds exist (Murthy, 1976).

Sulfuric Acid Scrubbing

The Chiyoda CT-101 process employs dilute sulfuric acid scrubbing. Liming follows the scrubbing step and an oxidation step. The process has been employed successsfuly in many Japanese plants, including a 250 Mw unit. High quality gypsum is produced; therefore, the Japanese are very satisfied.

Gulf Power Company in Florida has installed this system at the Scholz Power Plant on a 23 Mw unit. Results have not been analyzed yet.

Sodium Sulfite Scrubbing

The Wellman-Lord process employs a sodium sulfite scrubbing solution. The resulting bisulfite liquor is thermally regenerated in an evaporator-crystallizer to yield sulfur dioxide and recycled sodium sulfite.

The process was demonstrated by MKK, Japan, before 1974 (Beychok, 1974). The sulfur product was concentrated sulfur dioxide.

The first demonstration in the United States is at the Northern Indiana Public Service Company (NIPSCO) on a 115 Mw coal-fired unit. The 85 percent sulfur dioxide from the Wellman-Lord generator feeds an Allied Chemical reduction process which yields greater than 99.5 percent pure sulfur. Tests performed in August and September, 1977, determined sulfur dioxide removal efficiency of greater than 90 percent with particulate emissions achieving NSPS (Gaur, 1978).

ECONOMIC CONSIDERATIONS

Capital and operating costs for sulfur dioxide control technology considered to be commercially available are presented in Tables 9.6-4 and 9.6-5. Table 9.6-6 presents Busbar costs of coal-fired technologies. The desirability of using either naturally-occurring low-sulfur coal or beneficiated coal when possible is clearly indicated.

Section 8.2.3 of Chapter 8 presents an economic analysis of low-sulfur coal versus high-sulfur coal for the proposed units. As indicated, the results were similar to those presented in Table 9.6-4 and 9.6-5. Capital costs of FGD for the proposed units were estimated at $73 per kw (Florida Power Corporation, 1977). This cost, combined with an annual operating cost of $10 per kw (not including energy costs and replacement energy costs), does not make FGD economically attractive.

Table 9.6-4 Capital Costs for Commercially Available Continuous SO_x Control Technologies ($/kw)*

Control Technology	To the Utility		To the Coal Producer
Lime/limestone FGD	FGD Units	$54-69	
	Sludge Disposal	$10-50†	
	Total	$64-119	
Lime/limestone FGD with high coal beneficiation	FGD Units	$36-49	$16-23
	Sludge Disposal	$ 3-14†	
	Total	$39-63	
Lime/limestone FGD with moderate coal beneficiation	FGD Units	$42-54	$7-11
	Sludge Disposal	$ 4-20†	
	Total	$46-74	
Low sulfur coal**		$ 5-15	No increment for low- over high-sulfur coal
Coal beneficiation		Nil	$7-23

*Based on a new 1000 Mw plant using 3 percent sulfur Northern Appalachian Coal, meeting New Source Performance Standards.

†The utility may in some instances contract for sludge disposal, lowering its capital investment, while generally raising the operating cost.

**Coal meeting new source performance standards, i.e., 0.54 kilograms (1.2 pounds) SO_x per million Btu.

Source: Commerce Technical Advisory Board, 1975.

Table 9.6-5 Potential Capacities and Operating Costs of Commercially Available Continuous SO_x Controls.

Control Technology	Lead Time (Years)	Potential Capacity by 1980	Increase In Generating Costs (Mills/kwh)
Low sulfur coal*	3-6	20,000-40,000 Mw	4-7
Coal benefication	3-4	200-300 million tons coal per year†	0.5-2
Lime/limestone FGD	4-7	45,000-55,000 Mw	4-6**
-OR-			-OR-
Lime/limestone FGD With Lower Sulfur Coal	4-7	Somewhat more than 45,000-55,000 Mw for FGD alone	3-5††

*Coal meeting New Source Performance Standards, i.e., .54 kilogram (1.2 pounds) SO_x per million Btu.

†Only a minor fraction of the product meets SO_x emission standards.

**Based on a new 1,000 Mw plant using 3 percent sulfur Northern Appalachian Coal and meeting New Source Performance Standards.

††Use of the combined strategy instead of FGD alone reduces the sludge disposal and FGD capacities needed, thus increasing the capacity available by 1980.

Source: Commerce Technical Advisory Board, 1975.

Table 9.6-6 Busbar Costs for Coal-Fuel Technologies

Control Scenario	Busbar Power Costs, Mills/kwh
Direct Utilization	
Low-sulfur coal	25-28
Alkali scrubbing	28-34
Regenerative scrubbing	30-41
Fluidized bed combustion	27-42
Liquefaction	
Solvent refined coal	36-43
Petroleum-type fuel	41-48
Gasification	
Low-Btu gas (moving bed)	43-49
Medium-Btu gas (slagging moving bed)	35-41
Low-Btu gas (entrained)	32-37
Medium-Btu gas (entrained)	28-34

Source: Balzhiser, 1977.

Capital and operating costs of regenerative processes are also economically unattractive. The Chiyoda CT-101 (sulfuric acid scrubbing) process has an estimated investment cost between $80 and $100 per kw (Murthy, 1976). The Wellman-Lord process, which employs sodium sulfite scrubbing, has capital costs of between $63 kw and $117 kw. Operating costs are estimated at between 3 mills per kw and 6.3 mills per kw, including credit for the sulfur (Murthy, 1976; Gaur, 1978). While these processes are viable for Florida, they are not economically attractive.

9.6.3 PARTICULATE CONTROL ALTERNATIVES

Particulate control can be effected by the use of the following methods:

1. Wet scrubbers,
2. Fabric filters,
3. Mechanical separators, and
4. Electrostatic precipitators.

Process controls such as the use of excess oxygen and the use of low ash coal can reduce particulate emissions, but not to the levels required by NSPS. Very often, as discussed previously, specification of low sulfur coal results in high ash coal (western coals). Increased oxygen for more complete combustion will increase nitrogen oxides and sulfur trioxide conversion. It should not be required in a modern installation.

WET SCRUBBERS

Wet scrubbers remove dust by impaction and interception of particles onto fine water droplets. Their use has been limited in the past because of excessive energy consumption, large water volumes, required water treatment, and sludge disposal.

When used in conjunction with gas absorption and chemical reaction, scrubbers can be feasible particulate control devices. Tests conducted by Environmental Science and Engineering, Inc. (1973) on the magnesium oxide venturi scrubber at Boston Edison's Mystic Station indicated that 90 percent particulate removal can be accomplished during simultaneous sulfur dioxide removal. Tests conducted by EPA (Statnick, 1975), however, indicate that for fine particles, the efficiencies can actually be negative. A collection efficiency of 92.5 percent was achieved on particles in the 3.1 micron range. However, in the 0.30 micron particle range, a collection efficiency of minus 100 percent was experienced. The probable reason given for the poor performance was failure of the mist eliminator.

Better results were obtained at TVA's Shawnee Wet Limestone Scrubbing Test Facility. Good total collection efficiencies were observed on the venturi scrubber (greater than 90 percent); however, the efficiency dropped markedly in the submicron range. In a Turbulent Contact Absorber (TCA), overall efficiencies of greater than 99 percent were observed. The collection efficiency of submicron particles was greater than 90 percent at a pressure of 25.4 centimeters (10 inches) of water.

Unless coupled with sulfur dioxide collection, scrubbers are not economic solutions to particulate control. Even with sulfur dioxide control, mist must be controlled to insure good performance.

FABRIC FILTERS

Fabric filter media, such as baghouses, operate on the principles of impaction, interception, and diffusion of particles onto a filter cake. Baghouses have demonstrated higher collection efficiencies than electrostatic precipitators, particularly in the submicron range (Balzhiser, 1977), but suffer from the following disadvantages:

1. High maintenance costs, and
2. Large spatial requirements.

At efficiencies of less than 99 percent, fabric filters are not competitive with electrostatic precipitators. However, since efficiencies above 99 percent can be achieved with fabric filters, applications in congested areas may increase (Babcock and Wilcox, 1972).

MECHANICAL SEPARATORS

Mechanical separators such as cyclones depend upon centrifugal separation, and subsequent impaction, of particles from a gas stream. Particles of less than 10 microns are collected with efficiencies of less than 90 percent (Babcock and Wilcox, 1972). The use of mechanical collectors is possible only in conjunction with more sophisticated controls.

ELECTROSTATIC PRECIPITATORS

Electrostatic precipitators produce an electric charge on the particles to be collected, and then propel the charged particles by electrostatic forces to the collecting electrodes. The precipitator operation involves four basic steps (Babcock and Wilcox, 1972):

1. An intense, discharging field is maintained between the discharge electrode and the collecting electrodes.
2. The carrier gases are ionized by the intense, discharging field. These gas ions, in turn, charge the entrained particles.
3. The negatively charged particles, still in the presence of an electrostatic field, are attracted to the positively (grounded) charged collecting electrodes.
4. The collected dust is discharged by trapping into storage hoppers.

The collection efficiency of the electrostatic precipitator is related to the time of particle exposure to the electrostatic field, the strength of the field, and the resistivity of the dust particle. An efficiency of 99 percent is obtained at a cost generally favorable in comparison with other types of equipment. A very high percentage of particulate-removal units installed in commercial boiler plants since 1970 are electrostatic precipitators. Because of their inherent advantages in handling large volumes of flue gases with low pressure drop, efforts at EPRI and elsewhere are underway to improve their performance in the fine particulate range (Balzhiser, 1977).

9.6.4 NITROGEN OXIDES CONTROL ALTERNATIVES

Nitrogen oxides (NO_x) are formed by the oxidation of nitrogen compounds in the fuel, or by conditions of high temperature, pressure, and oxygen concentrations during combustion.

The extent to which power plants contribute to total NO_x emissions can be discerned from Table 9.6-7. Coal-, oil-, and gas-fired units account for over half of the NO_x emission from stationary combustion sources, and over one-third of the NO_x emissions from all sources.

Control of nitrogen oxides from coal-fired units at the present time is accomplished by use of low nitrogen fuel or by modified combustion techniques. The status of current control technology is summarized in Table 9.6-8. Flue gas recirculation is considered to be ineffective as an NO_x control method when applied at coal-fired units. Reduced combustion-air preheating and steam or water injection are considered to be noncompetitive in comparison with the other alternatives presented. The other control alternatives can be used separately or in combination to effect compliance with present day NO_x standards. These alternatives present no great problems from a technical point of view. In fact, Combustion Engineering guarantees that its equipment can meet the 0.6 pound NO_x per million Btu's that was expected in the summer of 1977 (Ricci, 1977). These units are almost identical to their older design furnaces, except the new units are larger, and have over-fire air.

In summary, no difficult decisions need to be made for NO_x control by the utility. Guarantees from manufacturers should suffice to insure that NO_x standards are met at the present time.

Table 9.6-7 Major Industrial Sources of NO_x Emissions

Rank	Source	Mass NO_x (metric ton/yr)	% Emissions, Stationary Sources	% Emissions, All Sources
1.	Coal-fired steam utility generators	3,495,000	30.8	15.6
2.	Fuel-burning reciprocating engines	2,132,000	18.8	9.54
3.	Oil-fired industrial/commercial boilers	1,245,000	11.0	5.57
4.	Oil-fired steam utility generators	1,114,000	9.80	4.98
5.	Gas-fired steam utility generators	835,100	7.35	3.74
6.	Coal-fired industrial/commercial boilers	734,600	6.45	3.29
7.	Gas-fired industrial/commercial boilers	491,400	4.32	2.20
8.	Fuel-burning turbine engines	253,300	2.23	1.13
9.	Cement manufacture	91,310	0.803	0.408
10.	Industrial/commercial space heating	80,560	0.709	0.360
11.	Crude distillation of petroleum	69,640	0.613	0.312
12.	Glass manufacture	68,160	0.600	0.305
13.	Catalytic cracking of petroleum	60,730	0.534	0.272
14.	Coal refuse piles (and abandoned mines)	30,590	0.269	0.137
15.	Nitric acid manufacture	27,050	0.238	0.121
16.	Vacuum distillation of petroleum	25,100	0.221	0.112
17.	Ethylene manufacture	24,020	0.211	0.107
18.	Wood-waste incineration	23,960	0.211	0.107
19.	High-density polyethylene manufacture	13,930	0.123	0.0623
20.	Propylene manufacture	12,600	0.111	0.0563
21.	Benzene manufacture	10,770	0.0947	0.0482
22.	C4 hydrocarbons manufacture	10,450	0.0919	.0467
23.	Brick kilns and dryers	8,680	0.0764	0.0388
24.	Mineral-wool manufacture	8,061	0.0709	0.0361
	Others	503,989	4.43	2.25
	TOTAL	11,370,000	100.17*	50.85

*Because of rounding.

SOURCE: Monsanto Research Corporation--Dayton Laboratory, 1976.

Table 9.6-8 Summary of Current NO_x Control Methods

Method	NO_x Reduction Gas	 Oil	 Coal
Flue-gas recirculation	60%	20%	Not effective
Reduced combustion-air preheat	50%	40%	Not effective
Steam or water injection	60%	40%	Not effective
Staged combustion	55%	40%	40%
Low excess air	20%	20%	20%
Reduced heat-release rate	20%	20%	20%
Combined staging, low excess air, and reduced heat release	50%	35%	40%
Change to fuel with lower % N	Not effective	40%	20%

Source: EPA report No. 650/2-74-066
U.S. Environmental Protection Agency, 1974.

9.6.5 SUMMARY

Table 9.6-9 is a summary of the advantages and disadvantages of the air pollution control alternatives. The preferred alternatives discussed in detail in Chapter 3 are:

1. Low-sulfur for sulfur dioxide emissions control,
2. Electrostatic precipitators for particulate emissions control, and
3. Boiler design for nitrogen oxide emissions control.

These alternatives discussed in the preceding section are the most reliable and cost-effective alternatives now known.

Table 9.6-9 Summary of Atmospheric Pollution Control System Alternatives

Pollutant	Control Scenario	Advantages	Disadvantages
Sulfur Dioxide	Low Sulfur Coal (compliance coal)	Meets NSPS without additional controls	Availability questionable
		Lower cost than other alternatives	Lower sulfur dioxide content in flue gases affects ESP performance
		No waste products (other than fly and bottom ash)	
	Coal Beneficiation (mechanical washing, magnetic separation, and chemical separation)	Least cost of control alternatives	Water utilization at mine
		Meets NSPS without additional controls, in some cases	Magnetic and chemical separation in laboratory stages
		Reduces amount of waste when additional controls are used	Most coals that were beneficiated would still not meet NSPS
	Solvent Refined Coal	Low ash and sulfur product	Processes still in development stage
		Higher Btu/lb fuel; therefore, lower transportation costs	More expensive than all other alternatives
		Can meet NSPS without additional controls	

Table 9.6-9 Summary of Atmospheric Pollution Control System Alternatives (Continued, page 2 of 6)

Pollutant	Control Scenario	Advantages	Disadvantages
Sulfur Dioxide (continued)	Dynamic Emissions Controls	Can comply with AAQS and PSD increments	Prohibited by Federal regulation
		Very low cost alternative	Will not meet NSPS
			Effectiveness uncertain
	FGD Throwaway Processes		
	1. Wet Lime/Limestone Scrubbing	Can remove up to 90 percent of sulfur dioxide	Produces large quantities of sludge that require large disposal area
		Considered commercially available	Potential for operation and maintenance problems
		Least expensive and most demonstrated of FGD processes	Potential for unit failure due to scrubber alone
			Lower plume exit temperatures resulting in greater ground level impact

Table 9.6-9 Summary of Atmospheric Pollution Control System Alternatives (Continued, page 3 of 6)

Pollutant	Control Scenario	Advantages	Disadvantages
Sulfur Dioxide (continued)	2. Double Alkali Scrubbing	Limited scaling, plugging, and erosion problems Proven successful in Japan on industrial boilers	Sludge produced has potential for water pollution Process is in research and development stages in the United States Loss of reactant (sodium hydroxide, ammonia or sodium sulfite) increases costs
	3. Limestone Addition	No semi-liquid sludge produced from process	Low sulfur dioxide removal efficiency does not allow NSPS to be achieved
	4. Fluidized Bed Combustion	Sulfur dioxide is removed in furnace and produces calcium sulfate (a dry waste) Heat transfer properties favorable	Not demonstrated on full-scale power plant Economics uncertain
	5. Dry Lime/Limestone Scrubbing	Dry waste product produced Potential for operation and maintenance minimized	Not demonstrated on full-scale power plant Rates of reaction must be adequately controlled

Table 9.6-9 Summary of Atmospheric Pollution Control System Alternatives (Continued, page 4 of 6)

Pollutant	Control Scenario	Advantages	Disadvantages
Sulfur Dioxide (continued)	FGD--Regenerative Processes		
	1. Magnesium Oxide Scrubbing	Small amounts of waste produced Potentially marketable by-product Reactant is recycled	Regeneration of reactant necessary More costly than wet limestone scrubbing Quantity of by-product may be too large to market
	2. Catalytic Oxidation	Small amounts of waste produced Potentially marketable by-product Reactant is recycled	More costly than wet limestone scrubbing Catalyst employed, contamination possible Quantity of by-product may be too large to market Corrosion problems in acid portion of facility

Table 9.6-9 Summary of Atmospheric Pollution Control System Alternatives (Continued, page 5 of 6)

Pollutant	Control Scenario	Advantages	Disadvantages
Sulfur Dioxide (continued)	3. Sulfuric Acid Scrubbing	Small amounts of waste produced Potentially marketable by-product produced Demonstrated in Japan	More costly than wet limestone scrubbing The high-quality gypsum may not be as economically attractive in the United States as in Japan Lower plume temperature can result in greater ground-level impact
	4. Sodium Sulfite Scrubbing	Small amount of waste produced Reactant is recycled Potentially marketable by-product	More costly than wet limestone scrubbing Lower plume temperature can result in greater ground-level impact
Particulate	Electrostatic Precipitation	Handles large quantities of flue gas at low pressure drop Removal efficiencies of 99.5 percent achievable Low maintenance costs Cost/Benefit more favorable than other control equipment	Highly dependent on coal utilized in boiler

Table 9.6-9 Summary of Atmospheric Pollution Control System Alternatives (Continued, page 6 of 6)

Pollutant	Control Scenario	Advantages	Disadvantages
Particulate (continued)	Fabric Filters	Potential for greater overall efficiency (especially in submicron range)	Larger space requirements than ESP's
		Can be utilized in dry lime/ limestone scrubbing applications	Limited design requirements
			Higher maintenance costs than ESP
	Wet Scrubbers	Can be combined with sulfur dioxide removal processes	Large volumes of water necessary
			Waste sludge produced with resultant disposal problems
			Lower plume temperature resulting in greater ground-level impact
			Excessive energy requirement
	Mechanical Separators	Very low capital, maintenance, and operating costs	Achievement of NSPS not possible

Note: Nitrogen dioxide control alternatives not summarized since the boiler can be designed to limit emissions.

Source: Environmental Science and Engineering, Inc., 1978.

9.7 WASTEWATER DISCHARGE SYSTEM ALTERNATIVES

9.7.1 OBJECTIVES

The objective of this analysis is to categorize the various wastewaters produced by the operation of the plant and to discuss methods for their disposal.

9.7.2 EVALUATION CRITERIA

The requirements are that all waters discharged from the plant site will be of a quality that complies with existing regulatory requirements, and that reuse of water will be incorporated to the greatest extent practical.

9.7.3 ALTERNATIVES CONSIDERED

SOURCES OF WASTEWATER DISCHARGES

The sources of wastewaters include circulating water, ash and sludge handling, rainwater runoff, and low volume wastewaters which consist of water pretreatment, ion exchange regeneration, metal cleaning, plant drains, sanitary waste, and boiler blowdown.

CIRCULATING WATER

Salt Water

If seawater is used as circulating water for condenser cooling on a once-through basis or as makeup to a cooling tower system, it will either evaporate, be lost to the atmosphere as drift, or be returned to the sea. In each case, shock chlorination would be required for control of biofouling of the condenser and cooling tower.

Cooling tower makeup would be at a constant rate regardless of generating unit load. The cycles of concentration of the circulating water will therefore vary between 1.1 and 1.2 depending on the cooling tower evaporation rate. The expected peak and normal cooling tower makeup requirement is approximately 4,289 dm^3/s (68,000 gpm, 97.9 mgd), based on such constant rate makeup pumpage.

Chemical analyses of makeup water, obtained from the existing intake and discharge canals, are shown in Table 9.7-1.

In the cooling tower scenario, blowdown flow at normal plant load (66 percent) for Units 4 and 5 would be 61,142 gallons (231.5 cubic meters) per minute. At peak load (100 percent), blowdown would be 57,727 gallons (219 cubic meters) per minute. The difference in blowdown flows results from greater evaporation at peak generating load.

With cooling towers, consumptive use from evaporation and drift at peak conditions will be 712 dm^3/s (11,280 gpm, 16.2 mgd), and 0.8 dm^3/s (13 gpm, 18,720 gpd) respectively, and 433 dm^3/s (6,870 gpm, 9.9 mgd), and 0.5 dm^3/s (8 gpm, 11,520 gpd), for normal conditions.

Blowdown temperature is expected to range from a minimum of 30°C (86°F) in January and February to a maximum 2-hour average of 35.6°C (96°F) in June, July, and August. Relevant chemical constituents of blowdown are expected to be as shown in Table 9.7-2.

Fresh Water

Quantity and Quality

At maximum evaporation of 41 cubic meters per minute (59,800 cubic meters per day) [11,000 gallons per minute (15.8 million gallons per day)], maximum drift of 0.15 cubic meters per minute (220 cubic meters per day) [40 gallons per minute (0.06 million gallons per day)], and operating at six cycles of concentration, the required blowdown from both units will be 8.18 cubic meters per minute (11,700 cubic meters per

Table 9.7-1 Gulf Coastal Salt Water Quality Data

Parameter	Range (mg/l)
Total Dissolved Solids	15,008 - 36,080
Vol. Dissolved Solids	2,348 - 7,884
Chloride as Cl	7,990 - 17,090
Calcium Hardness	610 - 1,000
BOD_5	0 - 15
COD	0 - 328
Total Iron	0 - 4.6
Total Copper	0 - 0.59
Total Zinc	0 - 0.15
Total Boron	0 - 5.9
Total Chromium	0 - 0.11
Total Lead	0 - 0.42
Total Arsenic	0 - trace
Total Mercury	0 - 0.8
Turbidity	0 - 80
pH	7.5 - 8.2
Conductivity (umhos/cm)	23,100 - 49,500

Source: Florida Power Corporation, 1977.

Table 9.7-2 Expected Quality of Saltwater Cooling Tower Blowdown for Crystal River Plant Units 4 and 5

Constituent	Cooling Tower Blowdown
Ca, mg/l as $CaCO_3$	1,300
Mg, mg/l as $CaCO_3$	5,330
Na, mg/l as $CaCO_3$	24,024
M Alk, mg/l as $CaCO_3$	157
SO_4, mg/l as $CaCO_3$	2,909
Cl, mg/l as $CaCO_3$	27,587
NO_3, mg/l as $CaCO_3$	1
SiO_2, mg/l as such	1
TSS, mg/l as such	30
Cl_2, mg/l as such	0.2 average 0.5 maximum
T-PO_4, mg/l as P	10
pH	8.0 to 8.5
Maximum 2-hour Average Temperature, C°	35.6°C

Source: Black and Veatch, 1978.

day) [2,160 gallons per minute (3.1 million gallons per day)]. Over the lifetime of the units, assuming 66 percent average annual load factor and average atmospheric conditions, the required blowdown will average 2.5 cubic meters per minute (3,600 cubic meters per day) [655 gallons per minute (0.9 million gallons per day)] per unit. The expected quality of freshwater tower blowdown is presented in Table 9.7-3.

Cooling water is continuously treated as necessary to adjust pH in order to limit scale formation. Organic phosphates are also added to inhibit scale formation. It has been common practice to add metals to prevent corrosion, but this is not planned.

In order to control bacterial, fungal, and algal growth, and to prevent fouling by invertebrates, biocides are added to the cooling water. This is discussed in the next section.

Biocide Treatment

Shock chlorination will be used in the circulating water systems for control of bacterial slimes and algae. The chlorination system will be controlled to limit free available chlorine to an average concentration of less than 0.2 mg/l and a maximum concentration of less than 0.5 mg/l in the blowdown discharged to meet the limits set by the EPA. In addition, the chlorination system will be controlled so that neither free nor total residual chlorine is discharged from any one of the units for more than two hours in any one day.

Blowdown to be discharged to the existing discharge canal will be taken from the cold side of the circulating water system as required by EPA regulations.

There will be a phosphate residual in the blowdown as a result of using an organic phosphate material for scale control.

Table 9.7-3 Expected Quality of Freshwater Tower Blowdown for Crystal River Plant Units 4 and 5

Constituent	Cooling Tower Blowdown
Calcium, mg/l as $CaCO_3$	1,000
Magnesium, mg/l as $CaCo_3$	443
Sodium, mg/l as $CaCO_3$	60
M-alkalinity, mg/l as $CaCO_3$*	200
Sulfate, mg/l as $CaCO_3$	1,219
Chloride, mg/l as $CaCO_3$	78
Nitrate, mg/l as $CaCO_3$	6
Silica, mg/l as SiO_2	26

*Based on feeding H_2SO_4 to control alkalinity to 200 mg/l, and utilizing an organic phosphate scale inhibitor.

Source: Black & Veatch, 1976.

Treatment and Disposal

Alternative disposal methods of cooling tower blowdown include injection wells and complete reuse and recycling. Neither of these alternatives were considered to be economically viable or necessary.

OTHER WASTEWATERS

Chemical Wastes

Quantity and Quality

Acidic and caustic chemical wastes will result from regeneration of ion exchange resins and from chemical cleaning operations (metal cleaning wastes).

It is estimated that the wastewaters from the makeup demineralizer will average 0.04 cubic meters (10 gallons) per minute, based on an average demineralized water demand of 0.66 cubic meters (173 gallons) per minute. The condensate polishing system wastewaters, assuming 50 regenerations of each resin bed per year, are estimated to average 0.008 cubic meters (2 gallons) per minute. The preoperational chemical cleaning wastes are estimated to be 4,500 cubic meters (1,200,000 gallons) in volume, with subsequent gallons of wastewater for each cleaning operation. Besides pH, potential causes of pollution are oil and grease, TSS, iron, copper and other metals, phosphates, organic compounds, and BOD from organic emulsifiers.

An acid wash is done every 3 to 5 years to remove scale and corrosion products from the boiler. The composition of this fouling depends upon boiler water composition and additives, boiler tube materials and leaked contaminants. The effluent is analyzed before each treatment is selected. Contents of the approximately 1,360 cubic meters (360,000 gallons) of cleaning water cannot be known ahead of time, but materials commonly found include calcium carbonate, calcium sulfate, $Ca_x(PO_4)$ silicates $Mg(OH_2)$, iron and copper oxides, zinc, nickel, aluminum, oil, and suspended solids.

Treatment and Disposal

A neutralization basin of approximately 378 cubic meters (100,000 gallons) capacity will be produced for treatment of chemical wastes prior to their ultimate disposal. A basin of this capacity would be sufficient to accommodate the wastewaters produced during regeneration of the ion exchange systems, and would handle the largest volume of chemical cleaning solution wastes at any one time.

The neutralization basin would be a reinforced concrete basin lined with chemical resistant membrane, brick, and mortar. A chemical waste mixer, mounted on the walkway spanning the open-topped basin, would be provided to hasten neutralization of the chemical wastes. Sulfuric acid and sodium hydroxide, as required for neutralization, would be available from the demineralization system regeneration equipment.

The neutralized chemical wastewaters would be conveyed to the Plant Drains Collection Pond for ultimate disposal. Pumping may be needed due to the distance. The Plant Drains Collection Pond would not normally overflow, as the exfiltration rate from the pond is expected to substantially exceed influent flows. During high rainfall events, the Plant Drains Collection Pond could overflow into the cooling tower blowdown conduit. The large quantities of rainfall runoff are expected to make any contributions from the neutralized chemical wastes insignificant. Alternatively, the Plant Drains Collection Pond could be sized for an eventuality exceeding the 10-year, 24-hour design storm and, relying solely on evaporation, exfiltration, and flow to the ash disposal area for dust suppression, would not include provision for surface discharge.

Water Pretreatment Waste

Quantity and Quality

A sludge consisting mainly of calcium carbonate produced in the solids contact unit, and backwash water from the gravity filters, will require disposal. Using the well water analysis presented in the Water Supply and Treatment System Analysis, 1.3 kilograms (2.9 pounds) of precipitate, predominantly calcium carbonate, will be formed per 3,785 liters (1,000 gallon) throughput. Assuming a 5 percent solids concentration in the sludge, a waste flow of about 0.015 cubic meters (2 gallons) per minute will result at the annual average service water demand condition of 0.98 cubic meters (259 gallons) per minute.

Assuming the gravity filters are backwashed weekly for 10 minutes at a rate of 0.06 cubic meters (15 gallons) per minute per square foot of filter area, the annual backwash waste flow is estimated at 0.02 cubic meters (6 gallons) per minute.

Treatment and Disposal

A desirable disposal point for the pretreatment system wastewater is the bottom ash system. The solid portion of the sludge, after dewatering, will be disposed with the bottom ash to the landfill. An estimated 500 kilograms (1,100 pounds) per day of pretreatment system solids will be disposed of in this manner. The pretreatment wastewater may need to be pumped from the pretreatment sludge sump to the ash system because of the elevations and distance.

Ash Handling

Quantity and Quality

Makeup water will be required for the ash water recirculation system to replace evaporation losses and the water entrained in the ash. At the annual average load condition, the estimated water losses from the bottom ash handling systems are as follows:

Evaporation losses	0.17	cubic meters (45 gallons) per minute
Entrained water in ash	0.068	cubic meters (18 gallons) per minute
Total makeup required	0.238	cubic meters (63 gallons) per minute

Wastewater from the water pretreatment system will be utilized as a source of makeup water. A small amount of service water will be required for the crusher seals and other services.

Treatment and Disposal

A dewatering operation will take place prior to transporting the ash to ultimate disposal. The decanted water will be recirculated and reused. None of the systems considered will involve direct discharge of ash handling water. Since the ash disposal area will be relatively flat, a perimeter ditch and dike system will be constructed to contain rainfall runoff which comes from the active ash disposal area.

The only wastewater from the ash systems that will require disposal will be rainfall runoff from the active ash storage area. The rainfall inside the active ash storage will be contained within the ditch and the dike and will be allowed to evaporate and exfiltrate within the area. The area within the dike will be about 8.1 hectares (20 acres) in size. The annual average rate of wastewater runoff generated by precipitation within the active ash storage area will be about 0.22 cubic meters (57 gallons) per minute.

The maximum 10-year, 24-hour rainfall event of 213 millimeters (8.37 inches) will result in approximately 12 cubic meters (3,160 gallons) per minute of runoff which will be contained within the active ash storage area ditch and dike. A rainfall event of greater than 213 millimeters (8.37 inches) in a 24-hour period will overflow the active ash storage ditch and dike entering the general site drainage system.

Miscellaneous Plant Drains

Quantity and Quality

Miscellaneous plant drains include wastewater from the roof and floor drain system and various equipment drains. Wastewater from the floor drain system results from plant cleaning and maintenance activities and from miscellaneous sources including equipment or pipe leakage, boiler blowdown, and relief valve drains.

Annual average flow rates of the contributors to the miscellaneous plant drains are 0.19 cubic meters (50 gallons) per minute.

Treatment and Disposal

Oil separation traps will be installed in all drains subject to contamination by oil or grease. The traps will be emptied by scavenging equipment for off-site disposal. The miscellaneous plant drainage system will be pumped to the Plant Drains Collection Pond. Normally, exfiltration from this pond is expected to exceed the input. Size of the Plant Drains Collection Pond will be adequate to handle a 10-year, 24-hour rainfall event in order to meet EPA requirements for runoff limitations.

The sources and quantities of plant wastewater directed to the pond at the annual average conditions are as follows:

Misc. Plant Drains	0.19	cubic meters (50 gallons) per min.
Neutralization Basin Effl.	.079	cubic meters (21 gallons) per min.
Pond Precipitation	.068	cubic meters (18 gallons) per min.
Total	0.337	cubic meters (89 gallons) per min.

Based on the 10-year, 24-hour rainfall event of 8.37 inches, the following are the maximum inflowing amounts to the Plant Drains Collection Pond.

Misc. Plant Drains	0.19 cubic meters (50 gallons) per min.
Neutralization Basin Effl.	0.11 cubic meters (28 gallons) per min.
Pond Precipitation	3.88 cubic meters (1,025 gallons) per min.
Total	4.18 cubic meters (1,103 gallons) per min.

The Plant Drains Collection Pond will be about 2.6 hectares (6.5 acres) in area to provide the necessary exfiltration. A minimum effective depth of about 0.91 meters (3 feet) is required to give a 24-hour retention time maximum flows. The pond will have a discharge and monitoring structure designed to prevent discharge of floating material. Discharge will be directed to the cooling tower blowdown conduit and then to the existing discharge canal. The structure will have provision either for grab sampling or for continuous monitoring as required by the EPA or Florida Department of Environmental Regulation.

Coal Storage Area Runoff

Quantity and Quality

Rainfall runoff from the coal storage areas on an average annual basis is as follows:

New Coal Storage Area 1	.30 cubic meters (80 gallons) per minute
New Coal Storage Area 2	.16 cubic meters (43 gallons) per minute

Using the 10-year, 24-hour rainfall event of 213 millimeters (8.37 inches) as a basis, the maximum runoff from the coal storage areas can be estimated as follows:

New Coal Storage Area 1	22 cubic meters (5,930 gallons) per min.
New Coal Storage Area 2	11.9 cubic meters (3,140 gallons) per min.

There is expected to be some pickup of suspended and dissolved solids in the wastewater from the coal, especially in the initial runoff water.

Treatment and Disposal

All coal storage area runoff will be directed to a perimeter ditch sized to contain a 10-year, 24-hour rainfall event to meet EPA discharge regulations for coal pile runoff.

It is expected that the exfiltration from the coal area rainfall runoff perimeter ditch will exceed the input in all but very heavy rainfall situations. The ditch will be equipped with overflows which discharge into the general site area drainage when rainfall runoff exceeds the holding capacity of the ditch.

General Site Area Runoff

Quantity and Quality

Rainfall runoff from the general site areas on an average annual basis is estimated at 0.4 cubic meters (85 gallons) per minute. Using the 10-year, 24-hour rainfall event of 213 millimeters (8.37 inches) as a basis, the maximum runoff from the general site areas can be estimated at 22.4 cubic meters (5,930 gallons) per minute. The runoff water may pick up some dissolved and suspended solids, especially in areas disturbed by construction.

Treatment and Disposal

General site area runoff will be directed to perimeter ditches. The ditches will be sized to contain a 10-year, 24-hour rainfall event.

Sanitary Wastes

Quantity and Quality

The maximum loading from Units 4 and 5 will occur with Unit 4 operating and Unit 5 under construction. Under these conditions, the estimated maximum hydraulic loading figures will be as follows:

100 permanent personnel (35 gpd*)	13.00	cmd†	(3,500 gpd*)
50 temporary personnel (25 gpd*)	4.73	cmd†	(1,250 gpd*)
40 visitors (25 gpd*)	3.8	cmd†	(1,000 gpd*)
1,000 construction personnel (20 gpd*)	76.00	cmd†	(20,000 gpd*)
Total	97.53	cmd†	

* gallons per day

† cubic meters per day

Biological loading will be approximately 0.034 kilograms (0.075 pounds) of BOD_5 per day for permanent personnel and approximately .020 kilograms (0.045 pounds) of BOD_5 per day for temporary personnel, visitors, and construction personnel, or a total of approximately 26 kilograms (57 pounds) of BOD_5 per day.

During commercial operation, the sewage treatment plant will process approximately 26 cubic meters (8,640 gallons) of sewage per day, containing approximately 8 kilograms (18 pounds) of BOD_5.

Treatment and Disposal

Consideration will be given to constructing a new sewage treatment plant for Units 4 and 5, or alternatively, transporting sewage to the existing sewage treatment plant.

New Sewage Treatment Plant--Plan I

Under this plan, a new sewage treatment plant (STP) would be installed to serve Units 4 and 5 only. The facility would be designed to achieve 90 percent reduction of BOD_5 and suspended solids, in accordance with the requirements of the DER. Chlorination would be provided to disinfect the plant effluent. The plant would be a 114 cubic meters (30,000-gallons) per day packaged, activate sludge unit which employs the extended aeration process method of treatment. Figure 9.7-1 (Black and Veatch, 1977) shows a possible location of this new sewage treatment plant. Effluent from the STP would be routed to a dedicated percolation

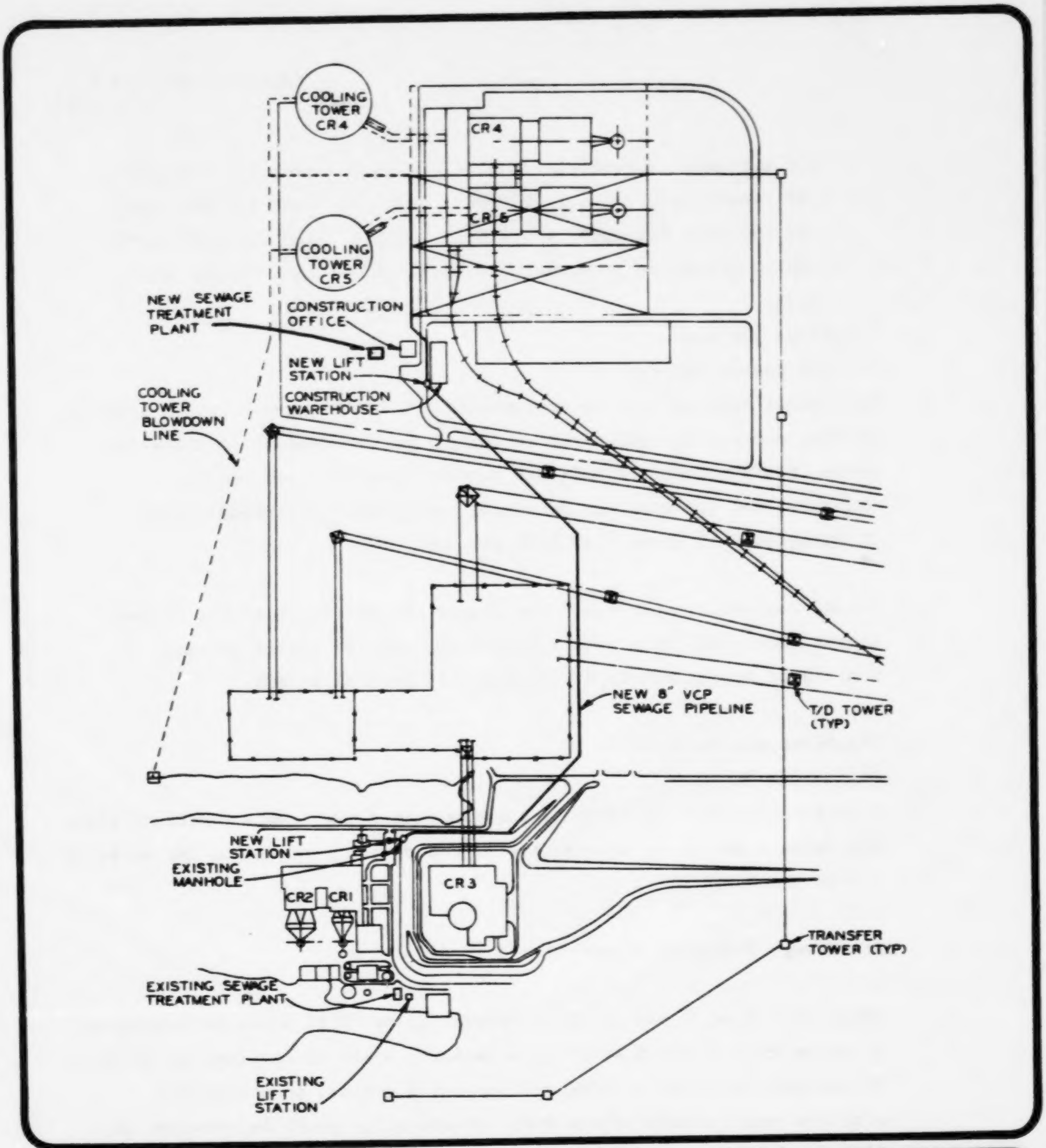

Figure 9.7-1
SEWAGE TREATMENT AND TRANSPORTATION

SOURCE: BLACK AND VEATCH, 1989

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pond for ultimate disposal. Sewage sludge either will be disposed of onsite in the ash landfill or will be removed by a commercial sludge disposal service.

Transporting Sewage to Existing Sewage Treatment Plant--Plan II

The existing facility has a capacity of 114 cubic meters (30,000 gallons) per day. The current average hydraulic load from Units 1, 2, and 3 is about 30 cubic meters (8,000 gallons) per day with reported maximum flows of 42 cubic meters (11,000 gallons) per day. The existing plant is capable of handling the additional wastes from Units 4 and 5 under most situations. However, with the maximum loading from operation of Units 1, 2, 3, and 4, and construction of Unit 5, the existing sewage treatment could be overloaded by several thousand gallons per day.

Transporting the sewage to the existing facility would require 820 meters (2,700 feet) more of 8-inch vitrified clay pipe than would a new sewage treatment plant. It is estimated that at least 12 additional manholes and 2 lift stations would be required to transport the sewage. Figure 9.7-1 shows the possible routing of this sewage piping. No significant additional operator attention and cleanup facilities would be required if the existing facility were utilized.

Capital costs for these plans are shown in Table 9.7-4. The operating costs and the comparative annual costs for the two plans are shown in Table 9.7-5. A new sewage treatment plant could be located in the cooling tower area, and the plant effluent could be routed to a dedicated percolation pond. Following completion of construction, the average sewage flow expected from Units 4 and 5 will be about 0.02 cubic meters (6 gallons) per minute.

Table 9.7-4 Comparative Capital Costs—Alternative Sanitary Waste Treatment Systems

Item	Plan I New Sewage Treatment Plant	Plan II Transporting Sewage to Existing Sewage Treatment Plant
Sewage	$ 50,000	$ 0
Operator's Wash Station	5,000	0
Sewage Piping and Manholes	Base	101,000
Lift Stations	Base	30,000
Subtotal	55,000	131,000
Interest During Construction at 42 per cent	23,000	55,000
Indirect Costs at 8.7 per cent	5,000	11,000
Total	83,000	197,000
Differential	Base	114,000

Source: Black and Veatch, 1977.

Table 9.7-5 Comparative Annual Costs--Alternative Sanitary Waste Treatment Systems

Item	Plan I New Sewage Treatment Plant	Plan II Transporting Sewage to Existing Sewage Treatment Plant
Operating Costs		
Energy	$ 1,500	$ 500
Operating Personnel	10,000	Base
Subtotal	11,500	500
Differential Operating Costs	11,000	Base
Demand Charge	800	300
Fixed Charge at 14 per cent	Base	16,000
Total	11,800	16,300
Differential	Base	4,500

Source: Black and Veatch, 1977.

DISCHARGE STRUCTURES

If saltwater is used for condenser circulation, the discharge structure requirements will be as discussed in Cooling System Alternatives, Section 9.5 of this document. If fresh water is used, the cooling tower blowdown discharge will also be located at the existing circulating water discharge canal. The maximum blowdown rate would be 10.4 cubic meters (2,750 gallons) per minute if water from Crystal River is utilized, and about half this magnitude if Lake Rousseau water is used.

If Lake Rousseau water is used for cooling tower makeup, one pipe approximately 10 inches in diameter will be required for blowdown. A 12-inch diameter pipe will be required if Crystal River water is utilized. The location of the discharge at the existing discharge canal will be such that the cooling tower blowdown can gravity feed into the canal.

9.7.4 COMPARATIVE ANALYSIS OF ALTERNATIVES CONSIDERED

INTEGRATED WASTEWATER MANAGEMENT

Suitable reuse and handling of wastewaters can reduce costs and minimize potentially harmful effluents. Table 9.7-6 summarizes sources of wastewater and their flow rates, characteristics, and possible reuses. Table 9.7-7 summarizes three alternative wastewater flow patterns which are schematicized in Figures 9.7-2, 9.7-3, and 9.7-4.

Each of the three wastewater flow schemes offers advantages as well as disadvantages. In Alternative 1, for example, boiler blowdown may be recycled either to demineralization or to pretreatment for reuse, rather than simply being bled off as waste as in Alternatives 2 and 3. On the other hand, Alternatives 2 and 3 handle stormwater runoff with efficient runoff retention collection systems rather than relying solely on grading and seepage through ground cover. A retention system may provide a measure of treatment through sedimentation and limited, naturally-occurring biological stabilization of the critical first flush of pollutant-containing runoff. Alternative 3 offers a distinct advantage over Alternatives 1 and 2, however, by virtue of the ash landfill in place of an ash pond for ultimate ash disposal. Land filling will enable disposal with the least adverse environmental impact by minimizing contact between ash and water, thereby minimizing both leachate production and the potential for surface discharge of pollutants.

ENVIRONMENTAL CONSIDERATIONS

Characterization and Volume of Wastewaters

There are two potential sources of fresh water for cooling, and sea water is a third possibility. Fresh water would be evaporated to a calcium concentration of about 1,000 ppm, allowing five or more cycles of concentration. The rate of blowdown would be 11,000 cubic meters (3 million gallons) per day or less. Sea water would probably go through less than 1.3 cycles of concentration. This would produce a

Table 9.7-6 Sources of Wastewater: Their Flow Rates, Characteristics, and Possible Reuses

Source	Volume	Content	Possible Reuses
Cooling blowdown, fresh water	3,400-11,000 cmd* (0.9-3 mgd)	pH 6-7, TDS, low level organic phosphates and chlorine	Ash transport
Cooling blowdown, salt water maximum	333,310 cmd* (88 mgd)	Salts 31 ppt, phosphates, chlorine	?
Demineralizer, condensate polisher	0.079 cmpm † (21 gpm)	H_2SO_4, N_2OH, concentrated minerals from freshwater inflow	Neutralizing, ash transport
Boiler cycle losses	.31 cmpm † (81 gpm)	High pH but low poise, still rather pure water	Recycle to demineralizer or for cooling tower makeup
Plant floor and equipment drains, all miscellaneous cleaning, etc.	0.19 cmpm † (50 gpm)	Oils, grease, pH, metals, no PCB's, phosphates, TSS	Ash transport
Roof drains	Average 0.08 cmpm † (Average 20 gpm)	TSS, rather clean	Most uses
Ash handling if 20 acres, 680 GPM exfiltrate, net rain gain 12.4 GPM	0.07 cmpm † 18 gpm entrained in ash	TSS, pH, metals, oil and grease	Recycle from pond for ash transport, entrained is lost
Coal runoff--Area 1	Average 0.3 cmpm † (Average 80 gpm)**	TSS, pH, metals, oil and grease	Neutralizing, ash handling
--Area 2	Average 0.16 cmpm † (Average 43 gpm)**		

Table 9.7-6 Sources of Wastewater: Their Flow Rates, Characteristics, and Possible Reuses (Continued, Page 2 of 2)

Source	Volume	Content	Possible Reuses
Sewage	Average <0.05 cmpm (Average <13 gpm)**	Nutrients, BOD, TSS	Irrigation of grounds, ash handling
Metal cleaning	1,200,000 gallons at start up 360,000 gallons every 3-5 years	pH, TSS, oil and grease, metals	Neutralizing, ash handling

*cubic meters per day = cmd
†cubic meters per minute = cmpm
**gallons per minute = gpm

Source: Black and Veatch, 1976.

Table 9.7-7 Wastewater Flow Alternatives

	Cooling Water	Service Water	Steam Cycle Water	Plant Drains Collection Pond	Wastewater Associated With Ash Disposal	Runoff Collection Retention System	Coal Storage
Alternate 1	From seawater Alternate addition from Lake Rousseau and pretreatment Blowdown discharge to Gulf via Long Channel	From wells Sewage effluent to cooling tower blowdown channel or groundcover irrigation Plant drains discharge to ash pond	From demineralizer Boiler recycle to demineralizer or pretreatment Condensate polishing utilized Waste effluent to ash pond No neutralization basin	Not included in this alternative	Ash Pond: Receives flow from plant drains system, cooling tower blowdown, rainfall, pretreatment, filtering condensate polishing Outflow to exfiltration, evaporation, overflow to cooling tower blowdown channel Ash storage: Incident rainfall overflow to cooling tower blowdown channel	Runoff controlled by grading and groundcover Inflow from roof drains and grounds Outflow to evaporation, exfiltration, cooling tower blowdown channel	(In conjunction with coal runoff pond) Receives rainfall Outflow to cooling tower blowdown channel, evaporation, exfiltration
Alternate 2	From seawater Alternate addition from pretreatment Blowdown discharge to Gulf via Long Channel	From wells Sewage effluent to cooling tower blowdown channel Plant drains discharge to plant drains collection pond	From demineralizer Boiler cleaning wastes, condensate polisher blowdown to neutralization basin	Receives flow from plant drains, neutralization pond, rainfall Outflow to ash pond, evaporation, exfiltration Overflow to cooling tower blowdown channel	Ash pond: Receives from plant drains collection pond, water pretreatment and filtering, cooling tower blowdown, rain Outflow to evaporation, exfiltration, ash storage Ash storage: incident rainfall overflow to cooling tower blowdown channel	Receives flow from ash pond, ash storage, coal storage, grounds, rainfall Outflow to evaporation, exfiltration, cooling tower blowdown channel	Receives rainfall Outflow to runoff collection system, evaporation, exfiltration

Table 9.7-7 Wastewater Flow Alternatives (Continued, page 2 of 2)

	Cooling Water	Service Water	Steam Cycle Water	Plant Drains Collection Pond	Wastewater Associated With Ash Disposal	Runoff Collection Retention System	Coal Storage
Alternate 3	From seawater Blowdown discharge to Gulf via Long Channel	From wells Sewage effluent to dedicated percolation pond Plant drains discharged to plant drains collection pond	From demineralizer Boiler cleaning wastes, condensate polisher blowdown to neutralization basin	Receives flow from plant drains, neutralization basin, boiler blowdown, rainfall Outflow to ash landfill for dust suppression, evaporation, exfiltration No overflow structure	Ash landfill: Receives flow from plant drains collection pond, ash and rejects handling, rainfall Outflow to exfiltration, evaporation, overflow to retention collection system	Receives direct rainfall, roof drainings, overflow from coal storage and ash landfill Overflow to discharge canal, evaporation, exfiltration	Receives rainfall Overflow to runoff collection system, evaporation, exfiltration

Source: Environmental Science and Engineering, Inc., 1980.

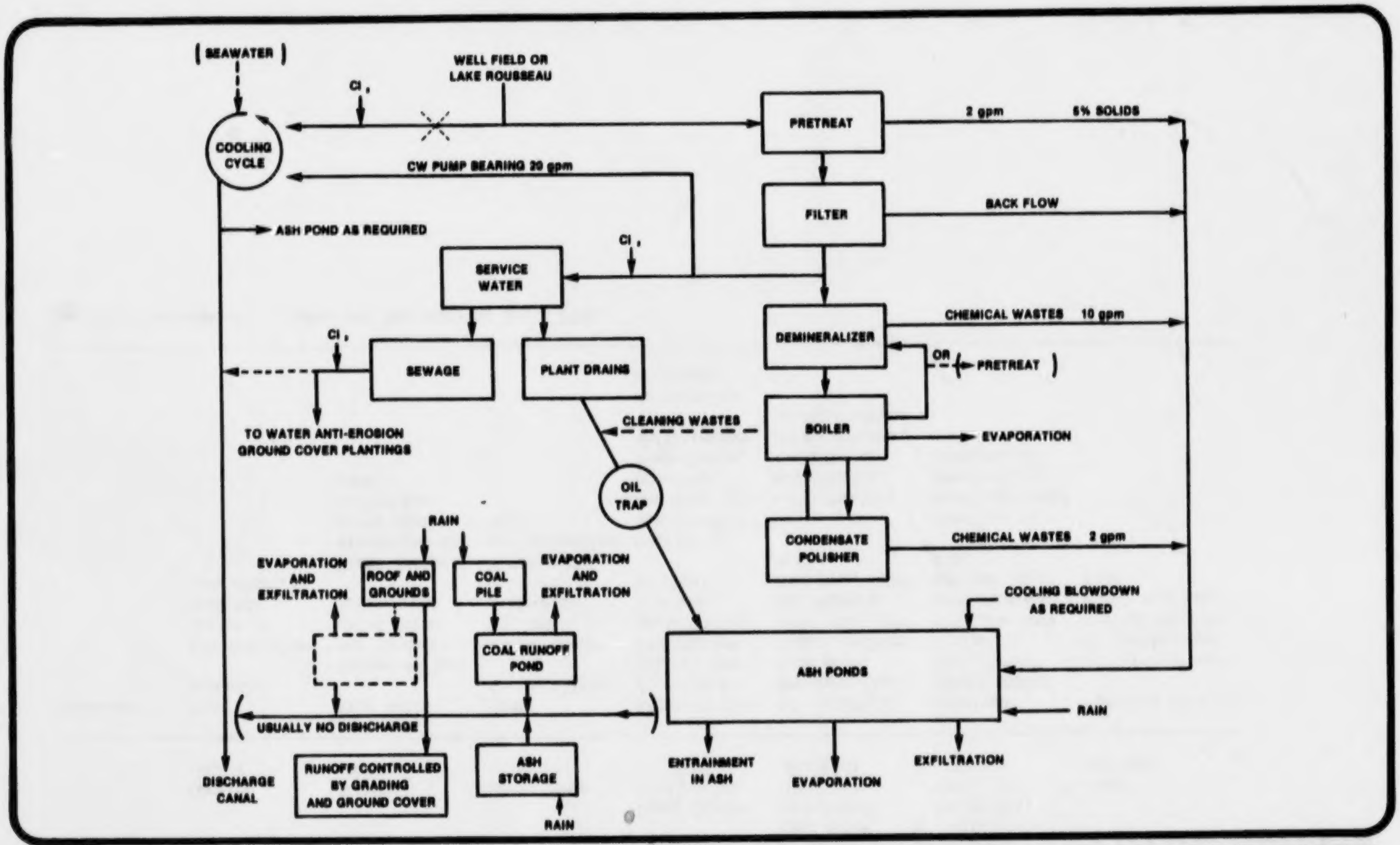

Figure 9.7-2
WASTEWATER FLOWS, ALTERNATE 1

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1980.

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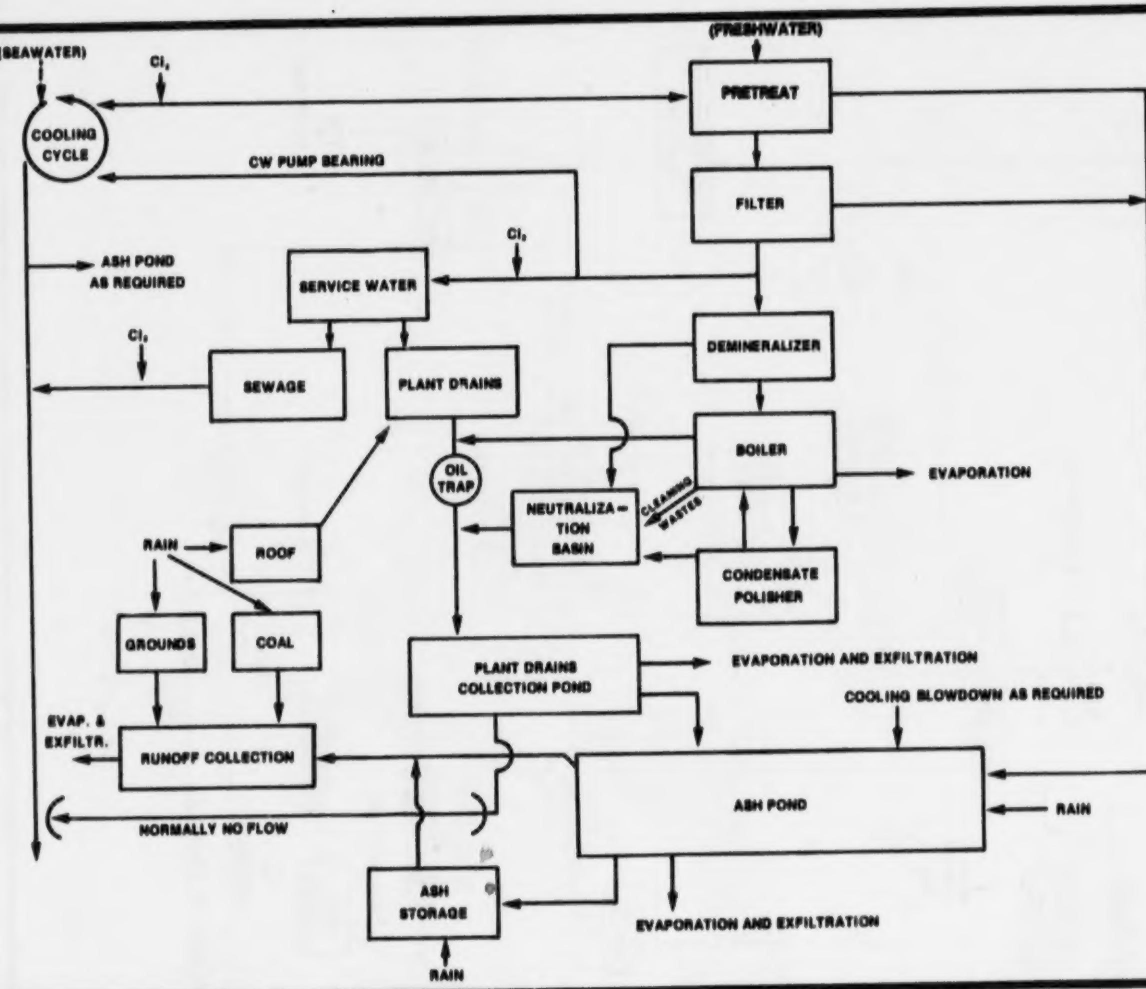

Figure 9.7-3
WASTEWATER FLOWS, ALTERNATE 2

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1980.

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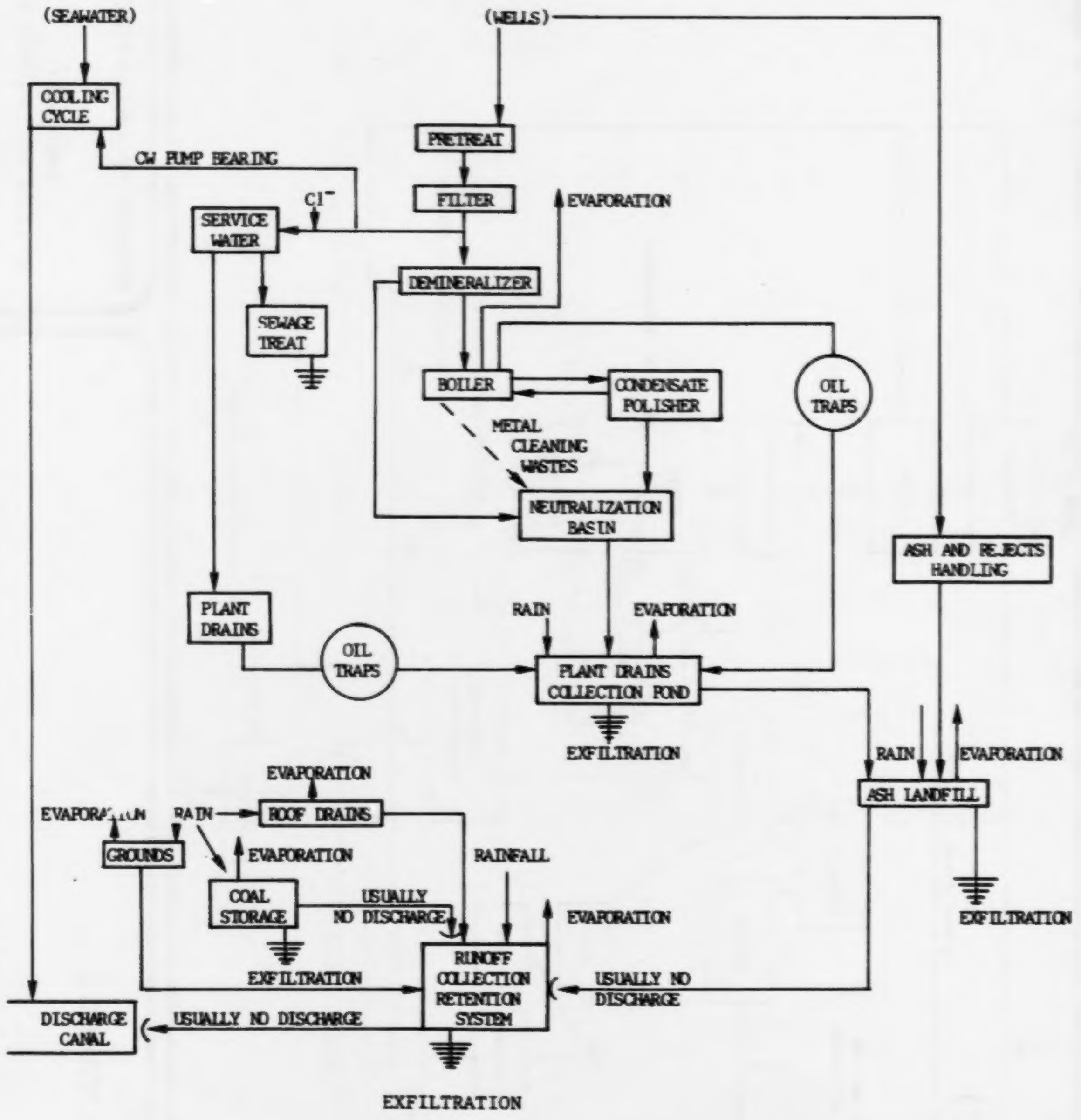

Figure 9.7-4

WASTE WATER FLOWS ALTERNATE 3

SOURCE: ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1980

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maximum of about 333,000 cubic meters (88 million gallons) per day of water at 31 ppt (intake=24 ppt). For either source, the evaporation rate is about 61,500 cubic meters (16 million gallons) per day maximum.

Cooling water is continuously treated as necessary to adjust pH in order to limit scale formation. Organic phosphates are also added to inhibit scale. It has been common practice to add higher phosphates and metals to prevent corrosion, but this is not planned because EPA does not allow any discharge of corrosion inhibitors. In order to control bacterial, fungal, and algal growth, and to prevent fouling by invertebrates, biocides are added to the cooling water.

Biocide Treatment Systems

The usual biocide for prevention of fouling is chlorine gas or hypochlorite. Shock treatment has been in common use and is now required by EPA in preference to continuous treatment. Discharge limit is an average of 0.2 ppm for no more than 2 hours per day (40 CFR 423.15 i and j).

Chlorine is highly toxic, but a summary of all available data suggests that 0.2 ppm is generally safe (Becker and Thatcher, 1973). As with all toxins, some species are much more sensitive to chlorine and are killed by considerably lower concentrations. Carpenter, et al. (1972) found that chlorine added at 0.1 ppm to cooling water intake with undetectable concentrations (<0.05 ppm) at discharge, reduced phytoplankton productivity in the discharge by 79 percent. There is some suggestion that this result is just a temporary lag in growth (Hirayama and Hirano, 1970); still, concentrations should be kept as low as possible. More recently, Toetz, et al. (1977) found that even at the very low initial concentration of 0.028 ppm (and actual exposure therefore less), chlorine depressed by 50 percent the nitrate uptake by phytoplankton.

However, these demonstrations are all of short-term effects. From laboratory experiment models of chlorination effects on marine phytoplankton, Goldman and Davidson (1977) concluded that chlorine toxicity is a function of biomass and that "...phytoplankton not killed by chlorination are capable of renewed growth once recovered, with no apparent permanent effects on growth rates." (species was Phaeodactylum tricornutum). Probably the most serious potential effect of chlorination arises from the still unknown fate and toxicity of organochlorine compounds.

Adding chlorine during the day might minimize effects, because ultraviolet speeds chlorine breakdown in sea water (Hostgaard-Jensen, et al., 1977). The effects of these bromine compounds and the effects generally of chlorination on marine ecosystems are almost completely unknown. The best available guide for residual chlorine remains the data of Brungs (1973—fresh water) and Becker and Thatcher (1973), cited above.

Chlorine can be chemically reduced by adding sodium bisulfate or sulfur dioxide, but the additions must be carefully gauged to avoid overcompensation and a new pollution problem. Such treatment is seldom performed, both because of the expense and because chlorine concentrations are usually low enough to be presumed safe and meet EPA requirements.

Ozone has been used in place of chlorine for disinfection and sterilization, but there is little experience with it in this country. It is a powerful oxident sometimes used as sewage biocide. Even with the high organic content of sewage, 3.5 ppm ozone for 20 minutes gives essentially complete kill (Bollyky and Siegel, 1977). Presumably the only byproduct is dissolved oxygen. The O_3 can be electrically generated as needed, so that the hazards of transport are less than with chlorine. However, ozone treatment may be more expensive than chlorine treatment. The concentrations used by Bollyky and Siegel (1977) were lower than previously thought effective, but cost data were not given. If the cost differential is small and if there are no detrimental side effects, ozone treatment should receive serious consideration.

Other methods of fighting fouling include osmotic shock, heating and drying of tubes, continuously running sponge rubber balls through the tubes, and antifouling paints. All of these have been tried, but are usually less effective than chlorination. However, some plants in the United States have found that the sponge rubber balls alone provide adequate cleaning. Environmentally, this would be the preferred cleaning method, because no biocides would be used. There is also an advantage in that balls with abrasive bands can be used to scrape scale from condenser tubes. However, the initial costs are relatively high, and the U.S. EPA estimates that the investment is not repaid unless other methods cannot achieve 80 percent cleanliness of tubes. Usually, other methods can maintain 95 percent cleanliness. If Lake Rousseau water were used for cooling, such a physical cleaning method might be justified by the potential of Corbicula fouling.

Toxins such as acrolein have been suggested as a slimicide. Normal dosage is approximately 0.2 to 1.0 ppm, but shock treatments of 3.0 to 5.0 ppm are sometimes used. Acrolein is highly flammable and quite toxic to mammals. Thiocyanates are effective against many microorganisms, and methylene-bis-thiocyanate is especially attractive because it supposedly is rendered harmless after 1 hour at pH 8. It would be an especially well-suited possibility in this situation with fresh water emptied into sea water.

Another potent biocide, 2,2-dibromo-3-nitrolo propionamide (DBNPA), would also hydrolyze rapidly in sea water. Its half-life is only two hours at pH 8, and rapidly decreases to only 2.5 seconds at pH 11.

Other biocides sometimes used include mixtures of chlorinated phenols. Toxicities of these compounds vary widely not only because of species differences, but also because of antagonistic and synergistic interactions with other substances. Even well below toxic levels, these phenols will give a disagreeable taste to the flesh of fish.

In summary, the best antifouling treatments from an environmental standpoint are the sponge rubber balls, which involve no biocides, and ozone, which leaves only dissolved oxygen. Unfortunately, the physical method is rather expensive and not always adequate by itself. Ozone has been used in some sewage plants, but apparently never by power plants. It is thought to be rather expensive, but no cost data are available.

Chlorine is effective, inexpensive, and very widely used. During long use, no obvious great environmental detriment has become apparent, although some recent research finds major effects from very low concentrations. Residual chlorine could be reduced with SO_2 or sodium bisulfate before discharge, although there is a danger of over-treatment and a new pollutant. Chlorine would seem to be the favored treatment, unless ozone becomes financially feasible.

Of the other biocides, DBNPA and methylene-bis-thiocyanate seem most promising for use at Crystal River because they are rapidly inactivated at the pH of sea water. However, no data are presently available on breakdown products or their effects.

Discharge to Sea

Blowdown from cooling towers could be discharged into the existing canal carrying once-through sea water from the three power plants presently on the site. This 2.4 kilometer (1.5-mile) long discharge canal carries 7,521 cubic meters (1,987 million gallons) per day. Added materials therefore would be diluted and mixed well before reaching open coastal waters. Cooling towers using salt water, which produce the maximum increase in salt load, would add a maximum of about 333,000 cubic meters (88 million gallons) per day of concentrated sea water to the canal. Thus a salinity increase of 0.54 percent from about 24 ppt to 24.13 ppt would result. This is substantially below the limits of any detectable salinity effect on ecosystems. Blowdown would be drawn from the cool side of the cooling tower, so that there would be no temperature increase relative to the present discharge.

Discharge Via Injection Wells

This alternative is expensive compared to surface discharge, and there is no reason to dispose of water resources in this way when other discharge methods appear acceptable. According to the EPA Administrator's Decision Statement 110.5, before using injection wells all alternatives must be explored and found less satisfactory with regard to environmental protection. This is not the case here, for discharge of blowdown to the sea appears to offer little potential for harm. Furthermore, new state laws in response to Section C of the Safe Drinking Water Act (PL 93-523) should be pending.

Zero Discharge

Techniques are available whereby part of the circulating water is continually desalinated and recirculated. All water received is evaporated off, with only salts to dispose of. Costs run approximately $1.00 per 3.8 cubic meters (1,000 gallons) for electrodialysis or reverse osmosis, totalling at least $328,000 per year for freshwater sources [3,400 cubic meters (0.9 million gallons) per day desalinated].

The volume of water saved would be extremely small compared to freshwater resources of the region, and would not justify the expense of zero discharge. Environmental effects of discharge can be minimal, and zero discharge appears not to be cost-effective.

Alternatively, the blowdown could be recirculated to other uses where water quality is not very critical. However, such use is limited to sluice water for ash transport, involving only 260 cubic meters (0.07 million gallons) per day.

Conclusions

The best method of disposal appears to be via the existing seawater discharge canal. Salinity increments after dilution would be less than 0.2 ppt. The only other additions would be chlorine, a low level of organic phosphate (scale retardant) and a pH lower than sea water. The levels of these will be low so that they will constitute very small increments to existing discharge.

Zero discharge significantly increases costs without noticeable savings to either the coastal ecosystem or regional water resources. It is thus not cost-effective. Local surface and ground water resources are large and currently little used. Some of the blowdown probably will be used in ash handling, but this would be a small portion of total discharge.

9.8 SOLID WASTE DISPOSAL SYSTEM ALTERNATIVES

9.8.1 OBJECTIVES

Coal-burning power plants produce large quantities of solid wastes. With increased use of coal in the future, impacts on solid waste production will also increase. The primary sources of solid wastes from coal-fired power plants are:

1. Bottom ash from furnace;
2. Fly ash from flue gas dust control equipment;
3. Sludge disposal from non-regenerative sulfur dioxide removal systems; and
4. Coal pulverizer rejects.

Typical wastes quantities from coal fired plants are given in Table 9.8-1. Values are for 3 percent sulfur coal. Florida Power Corporation expects about half of the ash for the "No Control" situation (Table 9-8.1) for Units 4 and 5.

If beneficiated coal is used, a large portion of the waste disposal can be accomplished before the coal is received by mine disposal. The major point made in the table is that if only high-sulfur coal is available at the mine, then coal beneficiation will provide the best option from a waste disposal point of view. If a substantial portion of the sulfur is of an organic nature, then moderate beneficiation followed by flue gas desulfurization (FGD) will provide the second best option. The worst situation is no beneficiation, large scale FGD, and no regeneration. If gypsum can be produced as a by-product, then the disposal requirements are similar to the "No Control" case.

Disposal of coal ash has been accomplished throughout the years by ponding or landfilling. Now, however, there is concern about leaching,

Table 9.8-1 Gross Surface Wastes for Commercially Continuous SO_x Emission Control Technologies*

	Limestone Requirements (tons/year)	Gross Wastes (tons/year) at the Utility		Gross Wastes (tons/year) at the Mine
		Ash	Sludge	Coal Refuse
No Controls † for comparison)		600,000		
Coal Beneficiation † (highest level for comparison)		165,000		720,000
Lime FGD (alone)	230,000	600,000	500,000	
Lime FGD (with moderate coal beneficiation)	100,000	220,000	240,000	500,000
Lime FGD (with high level coal beneficiation)	66,000	165,000	155,000	720,000

*Based on a new 1000 Mw plant using 3 percent sulfur Northern Appalachian coal, meeting New Source Performance Standards.
†Does not meet New Source Performance Standards.

SOURCE: Commerce Technical Advisory Board (CTAB), 1975.

and the advent of soluble FGD wastes causes even more concern. Therefore, disposal methods must be selected which protect the integrity of streams, ground water, and other aquatic systems.

9.8.2 ASH DISPOSAL

BOTTOM ASH

Bottom ash here is considered to be furnace slag. The material is relatively insoluble and usually poses no disposal problems. Slag can be disposed of as landfill or sold as road base material, granular material for roofing, aggregate for use in concrete blocks and preformed concrete, asphalt mix material, insulation, and grit for sandblasting (Babcock and Wilcox, 1977).

FLY ASH

The possibility of selling fly ash exists. Fly ash can also be landfilled. Alternatives can be designed to prevent dispersal of the fly ash in transport to the disposal site. Dustless unloaders and wetting methods can be used to alleviate fly ash dispersal.

ASH DISPOSAL ALTERNATIVES

Two ash disposal alternatives were considered for the proposed Units 4 and 5. The alternatives were disposal using: (1) a conveyor system and (2) a truck disposal system (Black and Veatch, 1976).

Conveyor System

In this alternative bottom ash and fly ash would discharge onto a belt conveyor and be transported to the disposal site.

The bottom ash, in a slurry form, would be transported to the dewatering operation. From the dewatering operations,the ash would be discharged onto the conveyors by means of vibrating feeders or chain-type conveyors for control of ash discharge onto the belt. Truck unloading capability would also be necessary for periods of conveyor maintenance.

The fly ash storage silo transfer system would incorporate dustless unloaders for discharge of fly ash onto the belt. Dustless unloaders, which discharge fly ash at a controlled rate along with water, will allow transportation of fly ash without generating dust. The fly ash silo transfer system would also require truck unloading facilities for use during conveyor maintenance periods or for offsite commercial sales.

A disadvantage of the conveyor system is controlling fly ash dust in loading and unloading operations and in blowout during conveyor travel. The dustless unloaders will be effective in reducing re-entrained fly ash. However, fly ash from western coals has a tendency to solidfy when mixed with water. This characteristic could cause operation and maintenance problems if major quantities of western coals are used, or if the design blend coal exhibits fly ash characteristics similar to western coals.

The conveyor system would utilize a 61-centimeter (24-inch) belt and be designed for 376 metric tons (415 tons) per hour. This conveying rate would be sufficient to transport the ash to the disposal site.

The conveyor system would include a permanent transfer house at the disposal site. From this transfer house to the more removed areas of the disposal site, the conveyor system would be constructed of 12-meter (40-foot) light frame sections mounted on skids. Three 30-meter (100-foot) portable conveyors would be used at the end of the conveyor for final direction of the ash. Conveyor sections would be moved and removed as ash is disposed.

Truck System

In this alternative, dewatered bottom ash and dry fly ash would be transported to the disposal site in off-highway rear dump trucks. Off-highway rear dump trucks would be used due to the large volumes of materials to be hauled, the relatively short haul distances, and the requirements for rapid loading and unloading of vehicles.

The off-highway dump trucks, which would be tandem drive axle type as commonly seen on construction and mining sites, are available from a number of manufacturers in sizes from 9 to 45 cubic meters (12 to 60 cubic yards). The trucks would be provided with an automatic latching, top hinged, swing tailgate with extra seals to ensure dust tightness. Advantages of these trucks are wide availability and salability, the high maneuverability inherent in short wheelbase design, and rapid loading and unloading capability.

Based on operation with the design blend coal, it is assumed that open top trucks would be used for both the bottom ash and fly ash transporting operations. The use of open trucks would have similar dust entrainment problems as the conveyor system. Similar to the conveyor system, the most effective method for dust suppression is the use of rotary dustless unloaders at the storage silo. With these unloaders, the fly ash would be wetted down in order to permit transportation to the disposal site in the open top trucks.

In the event cementation problems are experienced with the design blend coals, the trucks would be purchased with a design suitable for the use with removable top covers. With enclosed dump trucks, fly ash could be loaded in a dry state into the trucks. Silo telescopic spouts would be designed to fit tightly over the truck-loading aperture. A pressure relief opening in the truck would be vented into the fly ash storage silo. Dust emission during unloading would be minimized by the operation of the dump or tailgate. Dust suppression would be provided by water fogging.

The number of vehicles required to satisfy these parameters will be a function of vehicle capacity and haul distance. Based on an estimated round-trip time (load, loaded truck to disposal site, unload, return empty truck to loading area) of 20 minutes, five 22-cubic meter (30-cubic yard) trucks would be required for both Units 4 and 5.

Ash Disposal Operations

Ash landfill operations of the initial disposal site would be essentially the same for both the conveyor and truck systems. A perimeter dike approximately 0.9 meter (3 foot) high would be constructed to contain rainfall. Ash disposal would be initiated at the southern end of the disposal area and expanded to the north. This method of development would allow the western portion of the ash disposal area to be initially used for construction lay down purposes.

Rainfall runoff from the active disposal area would be collected in a drainage ditch system and retained within the disposal area. The landfill procedures would consist of (1) removing and stockpiling all soil materials within a given area, (2) deposition of the ash, and (3) covering with topsoil and seeding grass as each section is completed to the specified height.

The ash would be spread into lifts of 15 to 25 centimeters (6 to 10 inches) in thickness and rolled for optimum compaction density. Water fogging or sprays would be used in compaction and control of the ash dust. The following equipment would be used in landfill operations:

1. Compactors. A self-propelled dozer pulling a tapered shoe roller. A spreader blade would also be mounted on the front of the dozer.
2. Water Trucks. Water storage tank mounted on tandem axle truck. The truck would include an engine-driven pump, mounted boom, and portable hand-hose spray units.
3. Reclamation Equipment. Earth-moving equipment as required for "cut and cover" type procedures in the covering of ash. The type of equipment will be variable depending upon the intensity and nature of the reclamation operations at a given point in the disposal area life. It is projected that equipment would include a medium capacity bulldozer with "U" type blade supplemented periodically by a pan scrapper.

Disposal Area Alternatives

There are two design alternatives for the construction of the ash disposal area: (1) lining, or (2) not lining the ash disposal area. A discussion of the economic and environmental considerations of these alternatives follows:

Economic

Lining of ash disposal area would have an incremental cost over not lining the area. The costs would vary depending upon the type of liner. Lining could be accomplished by either a 30-centimeter (12-inch) impermeable clay layer or a PVC liner overlain with a 30-centimeter (12-inch) earth cover. The costs would be $958,320 for the clay liner and $1,742,400 for PVC liners.

Environmental

As both of the proposed liners would accomplish the same purpose, discussion will be limited to lining versus not lining the ash disposal area. The estimated environmental impact in either case is speculative due to uncertainties about ash leachate and runoff impacts.

No Lining--Potential impacts from not lining the landfill would consist of: (1) leachate getting into the groundwater and (2) rainfall runoff. According to some workers, leachate formed by the percolation of water through an active ash disposal area, will probably contain significant concentrations of Fe, SO_4^{-2} and other contaminants (Coutant, *et al*., 1978). These concentrations were attributed to oxidation and reduction reactions taking place in the ash. The effluent (leachate) was determined to have a biological impact. The same study also concluded that the direct effluent from ash slurry water generally showed little potential for significant environmental impact. This slurry water would not be unlike direct rainfall runoff from the ash area.

The probable impacts of this alternative will be mitigated by the design and operation of the ash disposal system. Since fly ash will be handled dry and the bottom ash will be dewatered, the available rainfall storage in the ash pond will be considerable. Frequent composting and covering of each ash lift will mitigate the possibility of leachate. The rainfall runoff will be diverted to the canal retention system.

Lining--With lining of the ash disposal area, the potential for direct leachate from the ash will be lessened. However, the potential for leaching from other areas or direct discharge will be present.

It is estimated that 0.15 cubic meters (55 gallons) per minute from rainfall would exfiltrate from an unlined ash disposal area. By lining the area, this water would have to be either exfiltrated into the drainage system or discharged directly. If this water were to remain in contact with the ash long enough to allow oxidation/reduction to take place, the resulting effluent could have a significant impact. As with the no-lining alternative, the design and operation of the landfill operations can mitigate these impacts.

A study is presently underway at the Units 4 and 5 which will monitor and test the leachate from the Ash Disposal Area. This study will establish lining needs in light of the geohydrology and geology of the Crystal River site. The monitoring study is discussed more fully in Section 6.2.3 of this report.

9.8.3 SCRUBBER WASTE SOLIDS DISPOSAL

If a FGD system is used, there is a potential for the generation of tremendous quantities of solid waste. With the use of limestone or lime scrubbing, the alternatives are sludge treatment followed by disposal or byproduct generation. The Commerce Technical Advisory Board (1975) has stated: "Options relating to sludge disposal entail large trade-offs in capital vs. operating costs. The broad range of capital required depends on the variability in the price and location of land for disposal, on the disposal method chosen, and on whether the utility chooses to contract with an outside organization for sludge disposal."

Alternative methods for byproduct generation have existed for years and more are being developed. Market conditions are important considerations before decisions can be made to manufacture gypsum from sludge. So far it has proven attractive only in Japan, where there is little disposal space and a high demand for gypsum.

Extensive research is being conducted to determine the ramifications of FGD waste treatment methods (Jones, 1977). Overall, the alternatives are:

1. Pond disposal;
2. Landfill disposal;
3. Mine disposal;
4. Ocean disposal;
5. Gypsum production.

POND DISPOSAL

The material in FGD sludge does not settle easily and is high in soluble compounds and COD. Ponding is possible if an impervious liner of clay or synthetic material is used to separate the sludge from ground water.

The problem with pond disposal is that ultimately the area must be reclaimed. Pond settling of untreated FGD sludge typically results in a concentrated slurry of less than 50 percent solids (Princiotta, 1975) which exhibits highly liquid behavior. Further dewatering to about 65-70 percent solids is required before physical stability is attained, and optimum compaction is achieved at about 80 percent solids (Rossoff, et al., 1974).

The wastes are very difficult to pump when there are more than 50 percent solids (Rossoff and Rossi, 1974). Since the pond is used as the primary dewatering mechanism, only those approaches that would greatly improve settling properties of the solids are applicable. Examples include: process modifications to increase the size of the sulfite crystals, oxidation to produce gypsum, and chemical treatment (Jones, 1977).

The Aerospace Corporation (Rossoff, et al., 1974) has established ponding costs varying from $5.50 and $10.00 per metric ton of dry solids, excluding pond reclamation costs.

LANDFILL DISPOSAL

The procedures for landfill disposal are similar to those for pond reclamation. Therefore, the sludge must be of a consistency that settles and thickens easily. The Duquesne Light Company has experimented with a fixing agent followed by a thickening operation. The final product is excellent for landfilling, according to Pernick (1977). Many other candidate fixing agents are being studied (EPA, 1976).

The problems are lessened somewhat if low-sulfur Western coal is used, because more of the sludge is in the sulfate (gypsum) form (Jones, 1977).

MINE DISPOSAL

Mine disposal of FGD wastes is logical in that coal cars leave empty from power plants after coal delivery. The major problems arise because of possible leaching of these wastes from the mine site. Certain types of mines in various locations do hold promise and are being investigated for their suitability in handling sludge by the Radian Corporation (U.S. Bureau of Mines Contract S0144135) and Arthur D. Little, Inc. (EPA Contract 68-03-2334).

OCEAN DISPOSAL

While ocean disposal is a possibility, many problems are indicated (Jones, 1977):

1. Ocean floor sedimentation;
2. Suspended solids;
3. Sulfate rich, high COD wastes;
4. Trace contaminants.

The following options are open which appear promising:

1. Dispersed disposal of sulfate-rich FGD wastes on the Continental Shelf,
2. Concentrated disposal of treated, brick-like FGD wastes on the Continental Shelf,
3. Dispersed disposal of sulfate-rich FGD wastes in the deep ocean,
4. Concentrated disposal of both sulfate-rich and treated FGD wastes in the deep ocean (Jones, 1974).

No doubt permits would be required, as well as environmental impact statements, before this alternative could be considered viable.

GYPSUM PRODUCTION

The prevailing attitude in the United States automatically ties FGD, by lime and limestone scrubbing, to sludge formation with insurmountable disposal problems. In Japan, a simple oxidation step makes it possible to produce dry gypsum, which is sold as a byproduct (Beychok, 1974). As of 1974, processes developed by Chiyoda, Mitsubishi, Nippon K.K., Show Dneko, and Kureha Chemical were in use for gypsum production in Japan.

In the sludge disposal problems discussed previously, the solutions were very often based upon the use of fixing agents, thickening, and even oxidation, to produce calcium sulfate. Probably by the time all costs are considered, including fixing and pond reclamation in the disposal alternatives, the revenues from gypsum production can offset the added cost of its production. Thus, in the long run, it might be the best all-around solution for the disposal of FGD slurry.

Gulf Power Corporation has employed a dilute sulfuric acid scrubbing process [Chujoda (T-101)] at its Scholz Generation Station in Chattahochee, Florida. Gypsum is produced as a by-product. Their costs should be analyzed as well as the marketability of the gypsum produced.

Gypsum production is a feasible alternative which has not been greatly promoted so far. The economics have not yet made it appear attractive. However, new attention given to the environmental problems of sludge disposal, and the costs of fixing agents and thickening, may give this alternative a higher priority.

9.9 TRANSMISSION FACILITIES ALTERNATIVES

9.9.1 EXISTING FACILITIES

The Crystal River site presently is served by two 500 kv transmission lines and four 230 kv transmission lines, all of which enter the site from the east. There is one 500 kv substation and one 230 kv substation.

The 500 kv substation is a three position ring bus arrangement with one transmission line exiting north (Crystal River, Central Florida), one transmission line exiting east, and one nuclear generation tie exiting south. The 230 kv substation consists of a four bay breaker and one-half arrangement with four transmission lines exiting north (double circuit Curlew Line, and double circuit Central Florida Line), two fossil-fuel generation ties exiting south, and two reserve auxiliary ties exiting south (one to fossil-fuel generation—Crystal River Units 1 and 2, and one to nuclear generation—Crystal River Unit 3). The substations are located so that all of the tie lines to existing power generation units are 180 meters (600 feet) in length or less.

9.9.2 FUTURE REQUIREMENTS

The proposed addition of two 640 Mw units at the Crystal River site will not require construction of any new transmission corridors, substations, or transmission lines other than ties to the existing substation which will require additional circuit breakers. Transmission planning has been based on the assumption that the first of the new generation units would be connected to the 230 kv substation and the second unit to the 500 kv substation. There would be one 230 kv reserve auxiliary transformer for the two new coal-fired units. The addition of these units would require the tie lines and some expansion of the existing substation facilities.

9.9.3 ALTERNATIVE TRANSMISSION SYSTEMS

The relevant criteria when evaluating alternative transmission systems in this case were that the length of the lines should be minimized, environmentally sensitive areas should be avoided, and transmission line crossings should be minimized for reasons of safety. Four transmission alternatives have been considered, corresponding to the four potential sitings of the power generating units.

Under the first alternative, serving location 1 with cooling tower, the tie lines would extend south from the power generation units, then would part and head east to the two substations (refer to Section 9.2). Both would exceed 910 meters (3,000 feet) in length. The line to the 500 kv substation would necessarily cross all four of the existing 230 kv lines serving the Crystal River complex. Both of the tie lines would cross wetland areas due to the location of the power generating units within the present coastal marsh.

The second alternative, involving location 2 with cooling towers, would require a 455-meter (1,500-foot) tie extending east and northeast to the 230 kv substation, and a line approximately 1.6 kilometers (1 mile) long to the 500 kv substation. The latter would cross the existing 230 kv lines and would extend across a fragile wetland area.

The third alternative would serve location 3, located southeast of the existing power generation units, and would require tie lines of 760 meters and 1,160 meters (2,500 and 3,800 feet), respectively. No power line crossings would be required in this case, and environmentally-sensitive areas would not be affected.

The fourth alternative would involve location 1c, in which the power generation units would be located directly north of the 500 kv substation. The tie lines in this case would extend west and south and would have total lengths of 1,000 and 1,300 meters (3,300 and 4,300 feet). No major effects to the coastal forest will result; however, the line to the 500 kv substation would again have to cross the existing 230 kv lines.

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Attachment 1. Program Review and Statistical Evaluation Synopsis;
Attachment 2. Water Quality Summary;
Attachment 4. Example of Physical Plant Data Format. Data is stored on computer tape;
Attachment 5. Synopsis of Research Publications of the Hydrographic Study;
Attachment 6. Thesis of Mr. Ronald Klausewitz containing Thermal Plume Model Verification;
Attachment 7. Source of Cooling Water Study;
Attachment 8. Summary of Phytoplankton Data;
Attachment 9. "Evaluations of Interactions between a Power Generation Facility and a Contiguous Estuarine Ecosystem." Samuel C. Snedaker and staff;
Attachment 10. Map of Approximate Macrophyte Standing Crop. Martin vanTine;
Attachment 11. Juvenile Fish Entrapment Study;
Attachment 12. Intake Velocity Measurements Taken at the Travelling Screens of Units 1 and 2;
Attachment 13. A Review and Annotated Bibliography of the Problem of Fish Entrapment at Power Generating Facilities.

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